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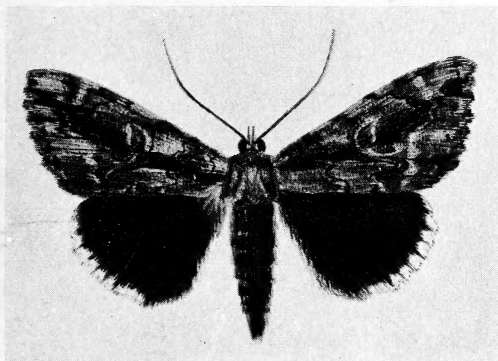
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### *Memoirs of the Lepidopterists' Society*, No. 1 (Feb. 1964) A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA

by CYRIL F. DOS PASSOS

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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## NOTES ON THE *BALANOTES* (MEYRICK) GROUP OF *OIDAEMATOPHORUS* WALLENGREN WITH DESCRIPTION OF A NEW SPECIES (PTEROPHORIDAE)

EVERETT D. CASHATT

Illinois State Museum, Springfield, Illinois

The separation of *Oidaematophorus balanotes* (Meyrick), *O. grandis* (Fish), *O. lacteodactylus* (Chambers) and *O. kellicottii* (Fish) has been difficult. Barnes and Lindsey (1921) used alar expanse and maculation, length of palpus and certain genitalic characters to distinguish these species. The accumulation of additional material, however, reveals that all of the above characteristics are subject to great variation within species. To more clearly define the taxa of this complex, an intensive study of the genitalia of both sexes was made. For males consistent differences between species were found in a secondary structure (hereinafter referred to as the "clasper") on the inner surface of the left valva. Differences in the anterior margins of the eighth tergites and in the configurations of the anterior apophyses aid in separating the females.

Non-genitalic characters were unreliable. Because it was difficult to associate males with females, the sexes were associated chiefly by localities. Further studies will include rearing larvae to confirm the relationships of the sexes.

### *Oidaematophorus balanotes* (Meyrick)

(Figures 1, 6, 9; Map 1)

*Pterophorus balanotes* Meyrick 1908: 503.

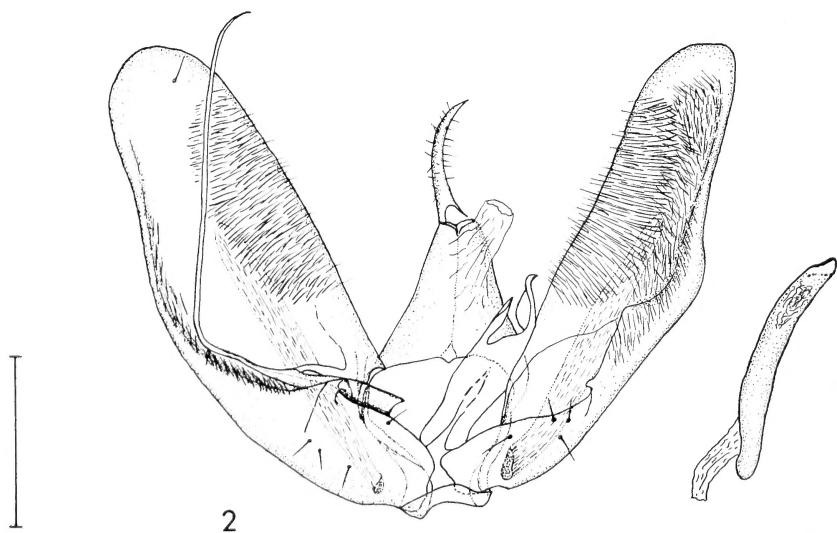
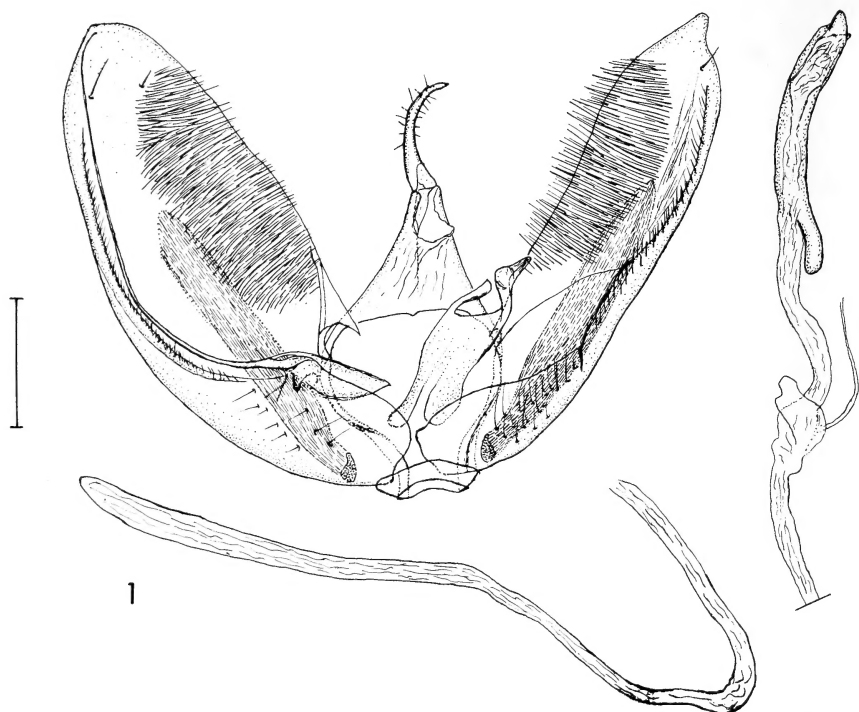
*Pterophorus aquila* Meyrick 1908: 503.

*Oidaematophorus balanotes*, Barnes and Lindsey 1921: 429.

**Alar expanse:** 31–42 mm.

**Head:** Scales brown, brownish white between antennal bases. Antenna brownish white. Labial palpus brownish white with brown tips, slender and erect, extending beyond antennal base.

**Thorax:** Scales brownish white. Forewing scales brownish white, an indistinct brown dash extending from base to near cleft; usually one or two small dark brown





spots proximad to cleft; tips of some or all veins dark brown (photograph in Barnes and Lindsey 1921: Pl. XLIV, Fig. 12). Hindwing brownish white to pale brown. Legs brownish white; foreleg and midleg brown mediad, midtibia more heavily scaled than other tibiae.

**Abdomen:** Scales brownish white with indistinct brown longitudinal lines on tergum, pleuron and sternum.

**Male genitalia** (Fig. 1): Tegumen triangulate. Uncus attenuate, curved ventrad. Vinculum narrow, arched ventrad. Valvae asymmetrical with hair-pencil tufts on outer surfaces; left valva longer and wider, apex pointed, inner surface with a long, curved, finely drawn clasper. Juxta well developed, directed toward right side, right arm extending beyond left. Aedeagus slightly curved, coecum well developed.

**Female genitalia** (Figs. 6, 9): Pouch for sex pheromone gland prominent (everted in drawing). Posterior apophysis long and slender. Anterior apophysis short, curved posteriad and ventrad. Tergite VIII with lateral margin excavate posteriad to anterior apophysis. Ostium bursae opening to left posterior margin of sternite VIII. Ductus bursae and corpus bursae membranous. Inception of ductus seminalis at anterior of corpus bursae, appendix bursae well developed.

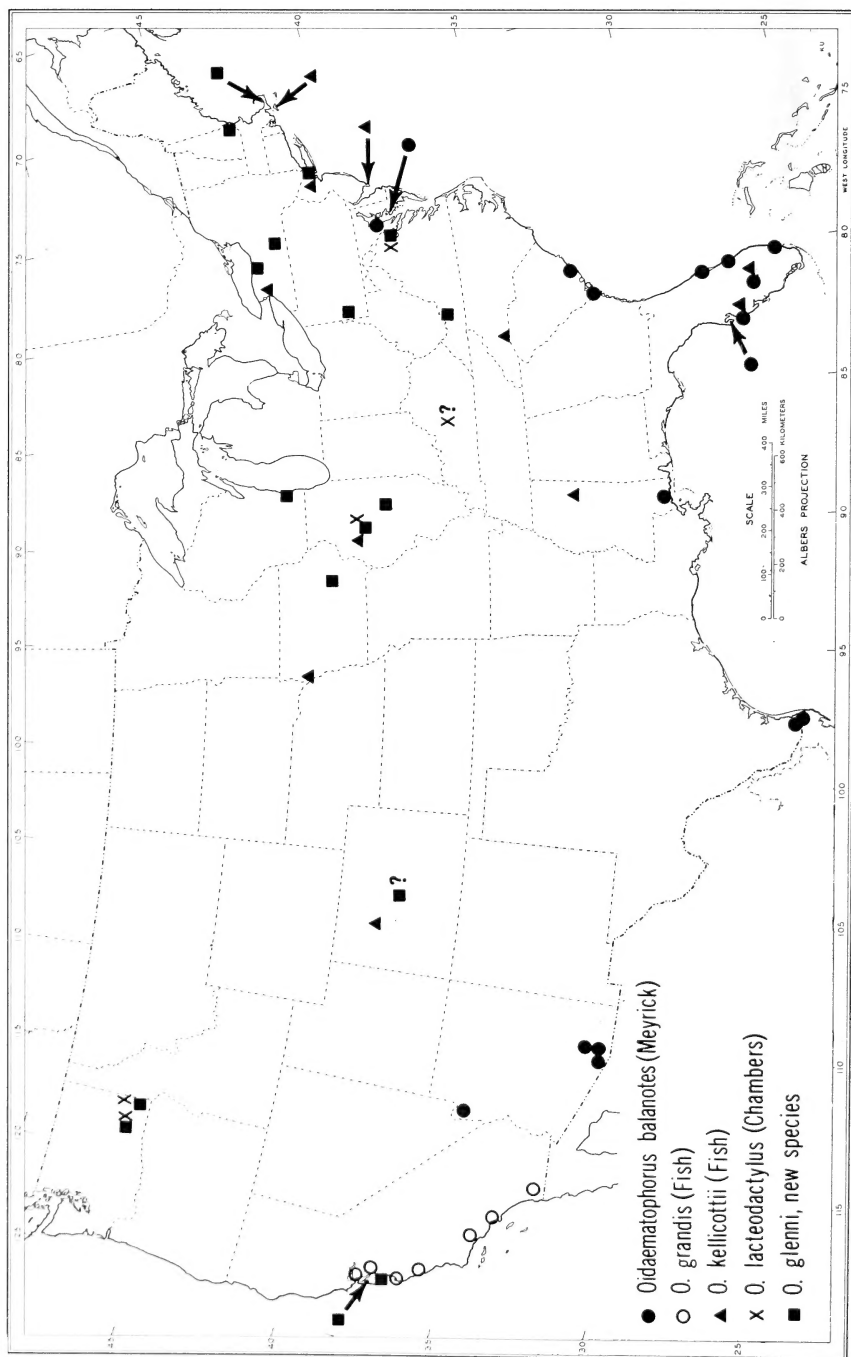
**Type data:** Holotype, male, Titusville, Florida, August, genitalia slide 10183, in collection of British Museum (Natural History); *P. aquila* Meyrick, holotype, female, Texas, in collection of British Museum (Natural History).

**Food plant:** Specimens in the U.S. National Museum Collection were reared from larvae which were boring in the stems of *Baccharis* sp. and *Myrica* sp.

**Specimens examined** (40 ♂♂, 38 ♀♀; Map 1): **UNITED STATES, Arizona:** Baboquivari Mtns., Pima Co., 1 ♀, Aug. 1-15, 1933, O. C. Poling (USNM); same locality, 4 ♀♀, Aug. 15-30, 1923, O. C. Poling (USNM); Madera Canyon, Santa Rita Mtns., 4880 ft., 2 ♂♂, Aug. 1-4, 1959, R. W. Hodges (USNM); Mohave Co., 2 ♂♂, Aug. 8-15 (USNM); Santa Catalina Mtns., Pinal Co., 2 ♂♂ Aug. 1-7 (USNM); same locality, 1 ♂, no date (USNM). **Florida:** Archbold Biological Station, Lake Placid, 1 ♀, May 1-7, 1964, R. W. Hodges (USNM); Lauderdale, 1 ♀, Feb. 11, 1923, D. M. Bates (USNM); St. Petersburg, 1 ♂, Jan. 31, 1951, R. Ludwig (USNM); same locality, 2 ♂♂, April 24, 1914, R. Ludwig (USNM), same locality 1 ♂, Dec. 30, 1914, R. Ludwig (USNM); same locality, 1 ♀, Feb. 8-15 (USNM); same locality, 1 ♀, March 1-7 (USNM); same locality, 1 ♀, Oct. (USNM); same locality, 3 ♂♂, 3 ♀♀, no date (USNM); Siesta Key, Sarasota Co., 5 ♂♂, Jan. 17-20, 1951, C. P. Kimball (CPK); same locality, 1 ♀, June 6, 1957, C. P. Kimball (CPK); same locality, 1 ♀, Feb. 14, 1956, C. P. Kimball (CPK); Titusville, 1 ♂, Aug. (BMNH); Vero Beach, 1 ♂, Feb., 1914, J. R. Malloch (USNM). **Maryland:** Highway 50 at South River, 1 ♂, Aug. 19, 1939, stem borer ex. *Baccharis* sp., J. F. G. Clarke (USNM); Lloyds, Dorchester Co., 1 ♂, 1 ♀, July 10, 1907, H. S. Barber (USNM). **Mississippi:** Landon, 1 ♀, Aug. 7, 1921, Larva in *Myrica* sp., L. E. Miles (USNM). **South Carolina:** Bluffton 1 ♀, Oct. 14, 1887 (USNM); Charleston, 1 ♀, July 9, 1898 (USNM). **Texas:** Brownsville, 1 ♀, June, F. H. Snow (USNM); same locality, 2 ♀♀, July 11, G. Dörner (USNM); same locality, 1 ♂, 2 ♀♀, ex. marsh willow, lot #44-27928; same locality, 1 ♀, Nov. 14, 1928, F. H. Benjamin (USNM); same locality, 1 ♂, Nov. 18, 1927, F. H. Benjamin (USNM); same locality, 1 ♂, 3 ♀♀, Nov. 27, 1928, F. H. Benjamin (USNM); same locality, 6 ♂♂, 4 ♀♀, no date (USNM); San Benito, 3 ♂♂, 1 ♀, July 16-23 (USNM); same locality, 1 ♂, 2 ♀♀, Aug. (USNM); same locality, 2 ♂♂, Sept. 8-15 (USNM).

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Figs. 1-2. 1, Male genitalia of *Oidaematophorus balanotes* (Meyrick), ventral view, aedeagus removed; 2, male genitalia of *Oidaematophorus grandis* (Fish), ventral view, aedeagus removed. (Scales = 1 mm.)



Because of its larger size, this species is not often confused with other related species in the southeastern United States. A West Coast species, *O. grandis* (Fish), is nearly as large, but slight genitalic differences and its apparent restriction to western California are sufficient to separate the two species.

Wing maculation and the clasper of the male genitalia are extremely variable. Specimens from the same locality and collected on the same date may have all, a few, or none of the forewing vein tips marked with dark spots. The forewing cleft is typically marked with one or two dark spots, but the spots are absent on some specimens. The clasper of the left valva is usually more curved at the base than it is at the middle, but the curvature of the clasper is more variable in *O. balanotes* than in the other species studied. The clasper of the holotype is acutely curved near the middle but seems to be within the range of the species. The tip of the right valva is more acutely pointed than in the other related species studied.

*Oidaematophorus grandis* (Fish)

(Figures 2, 10; Map 1)

*Lioptilus grandis* Fish 1881: 141.

*Alucita grandis*, Fernald, in Smith 1891: 87.

*Pterophorus grandis*, Fernald 1898: 50.

*Pterophorus baccharides* Grinnell 1908: 317.

*Oidaematophorus grandis*, Barnes and Lindsey 1921: 430.

**Alar expanse:** 30–34 mm.

**Head:** Scale coloration and palpus as in *O. balanotes*.

**Thorax:** Scales brownish white. Forewing brownish white with faded dark spots at tips of veins; cleft spot pale or absent (photograph in Barnes and Lindsey 1921: Pl. XVII, Fig. 7). Hindwing pale brownish white to grayish white. Legs identical to those of *O. balanotes*.

**Abdomen:** Scale coloration as in *O. balanotes*.

**Male genitalia** (Fig. 2): Much like *O. balanotes* except clasper on left valva more acutely curved near base and right valva with a slight lobe near middle of hind margin.

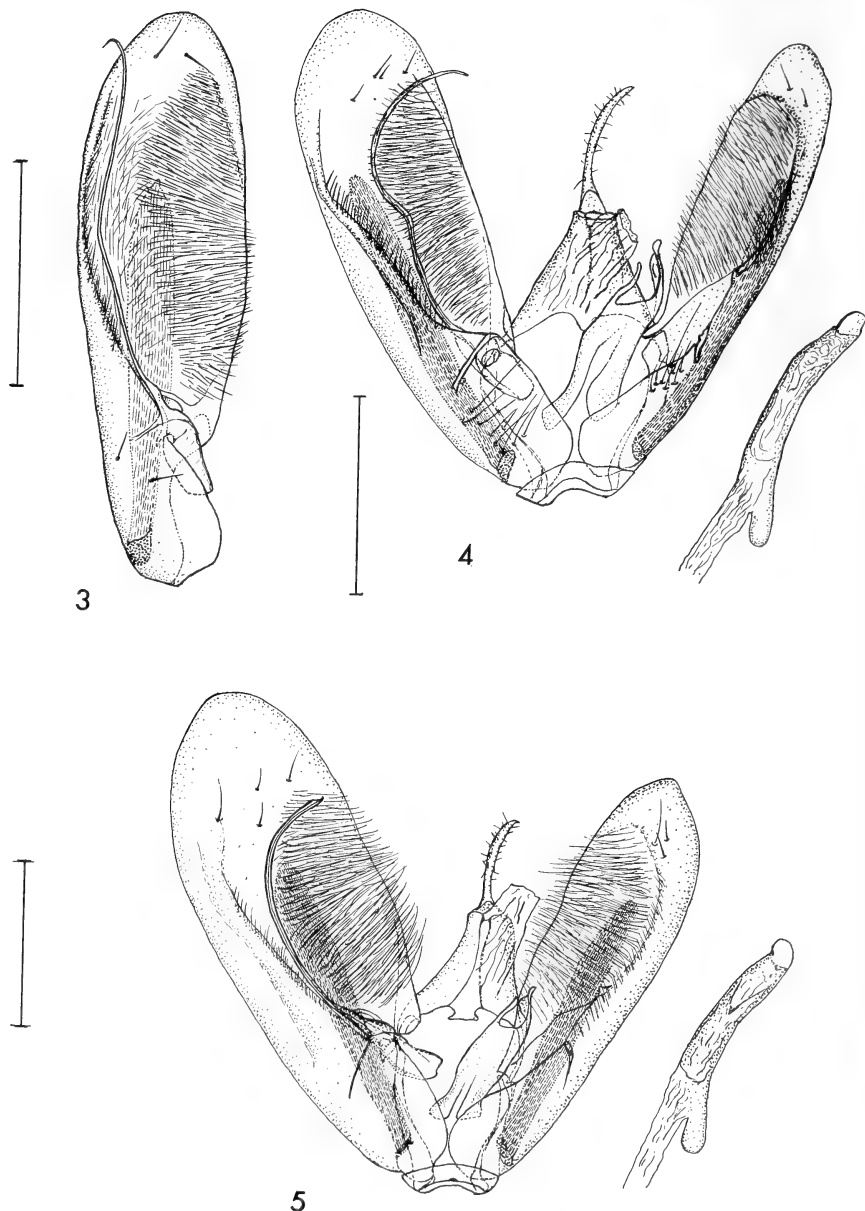
**Female genitalia** (Fig. 10): Identical to those of *O. balanotes* except anterior apophysis shorter and slightly thicker.

**Type data:** I hereby designate a male in the collection of the Museum of Comparative Zoology as lectotype, labeled: "California, 1782," genitalia slide EDC 258. Two paralectotypes (without abdomens), one male and one broken specimen, from California are in the collection of the U.S. National Museum. Grinnell's two syntypes of *P. baccharides* were not examined.

**Food plant:** The larvae bore in stems of *Baccharides pilularis* DC. Additional notes on the immature stages were recorded by F. X. Williams (in Barnes and Lindsey 1921: 431–432).

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Map 1. Distribution records for *Oidaematophorus* spp. It is important to note that these records perhaps indicate the distribution of *collectors* of *Oidaematophorus* rather than the actual distribution of the species.



Figs. 3-5. 3, Left valva of *Oidaematophorus kellicottii* (Fish), ventral view; 4, male genitalia of *Oidaematophorus lacteodactylus* (Chambers), ventral view, aedeagus removed; 5, male genitalia of *Oidaematophorus glenni* Cashatt, n. sp. ventral view, aedeagus removed. (Scales = 1 mm.)

**Specimens examined** (10 ♂♂, 2 ♀♀, Map 1): **UNITED STATES, California:** Berkeley, 1 ♂, June 10, 1931, Don Meadows; Carmen, 2 ♂♂, June, A. A. Vachell; Los Angeles Co., 1 ♂, May, C. V. Riley; Mills College, Alameda Co., 1 ♂, 1 ♀, June 27–30, 1908, G. R. Pilate; Monterey Co., 2 ♂♂, June 10, 1908, F. X. Williams; San Felipe Valley, San Diego Co., 1 ♀, Sept. 5, 1937, Don Meadows; Santa Clara, 2 ♂♂, no date; Wheeler Hot Springs, 1 ♂, July 29, 1943, (all USNM).

Barnes and Lindsey (1921: 432) noted that a specimen (female) of *O. grandis* labeled "Plummer's Island, Maryland, May" was probably an error either in their record or on the label. After dissecting the genitalia of this specimen, I find it to be *O. glenni* described below.

Notes on the genitalia will aid in separating this western species from *O. glenni* in California.

### *Oidaematophorus kellicottii* (Fish)

(Figures 3, 11; Map 1)

*Lioptilus kellicottii* Fish 1881: 141.

*Alucita kellicottii*, Fernald, in Smith 1891: 87.

*Pterophorus kellicottii*, Fernald 1898: 49

*Pterophorus kellicottii* (sic), Meyrick 1910: 17.

*Oidaematophorus kellicottii*, Barnes and Lindsey 1921: 427.

**Alar expanse:** 20–28 mm.

**Head:** Scales light brownish white. Labial palpus slender and erect, but not reaching antennal base.

**Thorax:** Scales light brownish white. Forewing scales brownish white with an indistinct brownish dash extending from base and fading out toward cleft; usually a dark spot at base of cleft; tips of some or all veins marked with a small dark brown spot (photograph in Barnes and Lindsey 1921: Pl. XLVII, Fig. 5). Hindwing brownish white to pale brown. Legs identical to *O. balanotes*.

**Abdomen:** Scale coloration as in *O. balanotes*.

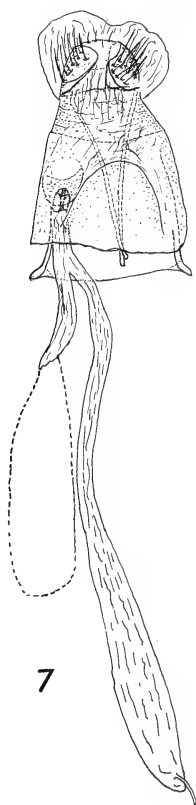
**Male genitalia** (Fig. 3): Similar to those of *O. balanotes* except smaller; tips of valvae more rounded; clasper slightly shorter and directed laterad or mediad, distal half straighter, curvature more acute near base and at tip.

**Female genitalia** (Fig. 11): Similar to those of *O. balanotes* except tergite VIII with anterior margin rounded; anterior apophysis straight and directed laterad.

**Type data:** Lectotype, male, without abdomen, and one female paralectotype, Buffalo, New York, no date, in U.S. National Museum.

**Food plant:** The larva bores into the stems of *Solidago*. The food habits were studied by Kellicott (in Barnes and Lindsey 1921: 429).

**Specimens examined** (10 ♂♂, 7 ♀♀; Map 1): **UNITED STATES, Colorado:** Glenwood Springs, 1 ♂, June 8, 1893, W. Barnes (USNM). **Florida:** Archbold Biological Station, Lake Placid, 1 ♂, June 1–8, 1964, R. W. Hodges (USNM); St. Petersburg, 1 ♀, May (USNM); Siesta Key, Sarasota Co., 1 ♂, Feb. 18, 1956, C. P. Kimball (USNM); same locality, 1 ♀, May 18, 1963, C. P. Kimball (CPK). **Illinois:** Putnam Co., 1 ♂, 2 ♀♀, July 7, 1961, M. O. Glenn (MOG); same locality, 1 ♂, July 16, 1960, M. O. Glenn (MOG). **Iowa:** Sioux City, 1 ♀, July 15, 1917, A. Lindsey (USNM). **Massachusetts:** Martha's Vineyard, 1 ♀, July 19, F. M. Jones (USNM). **Mississippi:** Agriculture College, 1 ♂, July 23, 1920, F. H. Benjamin (USNM). **New Jersey:** Anglesca, 1 ♂, May 28, 1905, W. D. Kearfott (USNM); Essex Co. Park, 1 ♂, Aug. 2, 1906, W. D. Kearfott (USNM); no data, 1 ♂, D. S. Kellicott (USNM). **New York:** no locality, 1 ♀, Oct. 16, 1880, Fernald Coll., labeled "type" (USNM). **North Caro-**





**lina:** Tryon, 1 ♀, June 2, 1904, Fiske (USNM); same locality, 1 ♂, Aug. 4, 1904, Fiske (USNM).

The genitalia of this species are nearer those of *O. balanotes* than those of the other species; the differences are described above. Specimens of *O. kellicottii* are generally smaller and have a single distinct spot at the base of the cleft.

*Oidaematophorus lacteodactylus* (Chambers)

(Figures 4, 7, 12; Map 1)

*Pterophorus lacteodactylus* Chambers 1873: 72.

*Alucita subochracea* Fernald, in Smith 1891: 87 (*in partim*).

*Pterophorus subochraceus*, Fernald 1898: 43 (*in partim*).

*Oidaematophorus lacteodactylus*, Barnes and Lindsey 1921: 426.

**Alar expanse:** 27–29 mm.

**Head:** Scale coloration and palpus as in *O. balanotes*.

**Thorax:** Scales brownish white. Forewing brownish white with diffuse light brown dash extending from base and fading near cleft; one or two indistinct brown spots at base of cleft; tips of some or all veins marked with dark brown (photograph in Barnes and Lindsey 1921: Pl. XLVII, Fig. 6). Hindwing brownish white. Legs identical to those of *O. balanotes*.

**Abdomen:** Scale coloration as in *O. balanotes*.

**Male genitalia** (Fig. 4): Similar to those of *O. kellicottii* except distal one-third of clasper more broadly curved and not as finely drawn, tip of right valva not sharply pointed.

**Female genitalia** (Figs. 7, 12): Similar to those of *O. kellicottii* except anterior apophysis shorter, anterior margin of tergite VIII only slightly rounded.

**Type data:** Holotype, male, Kentucky, no abdomen, in the collection of the Museum of Comparative Zoology.

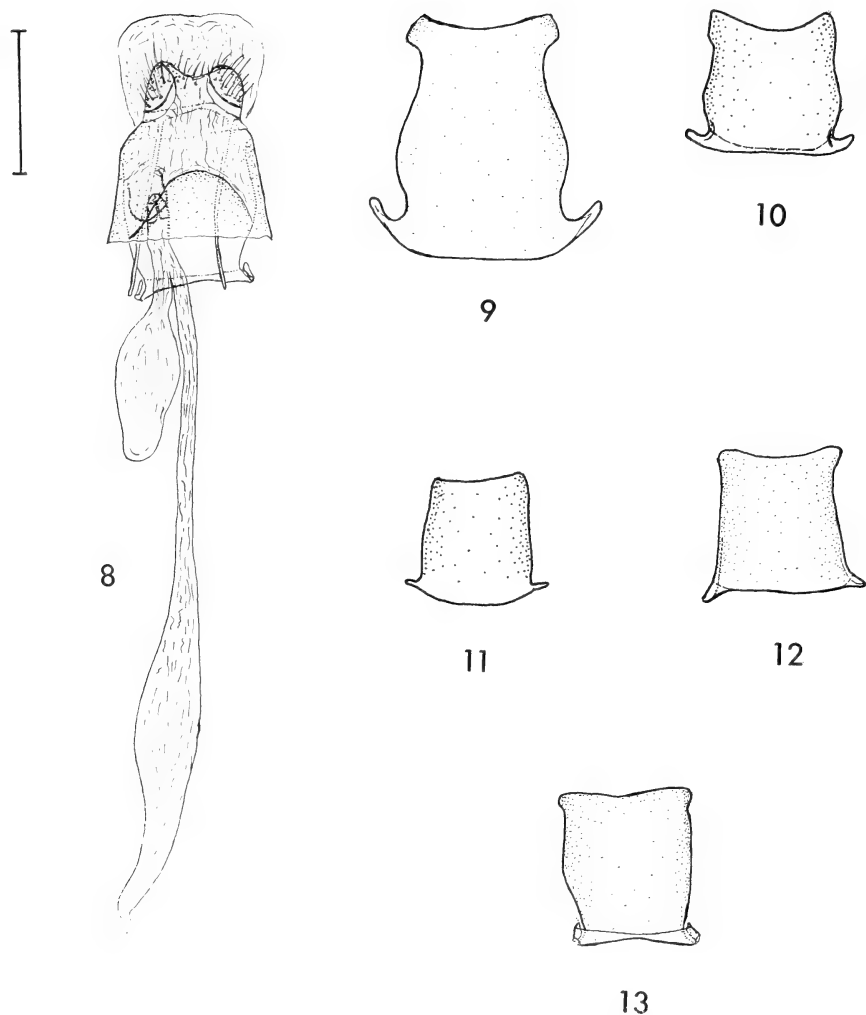
**Food plant:** Dr. J. F. G. Clarke reared specimens which were boring in stems of *Solidago* sp. in Washington.

**Specimens examined** (10 ♂ ♂, 4 ♀ ♀; Map 1): **UNITED STATES, Illinois:** Putnam Co., 2 ♀ ♀, July 8–11, M. O. Glenn (MOG). **Kentucky:** no further data, 1 ♂ (MCZ). **Maryland:** Plummer's Island, 1 ♂, July 1, 1903, A. Busck (USNM). **Washington:** Almota, 8 ♂ ♂, 2 ♀ ♀, May 2–26, reared from *Solidago* sp., J. F. G. Clarke (USNM); Pullman, 1 ♂, May 15, 1935, J. F. G. Clarke (USNM).

The identity of this species has been confusing. Barnes and Lindsey's illustration (1921: Pl. LIV, Fig. 2) of the male genitalia matches a slide labeled "*O. lacteodactylus*, 67551" in the U.S. National Museum Collection. Since the abdomen of the type specimen is lost, I am unable to compare the type's genitalia with those of the study material. Most specimens that I have examined have a slight outward bend near the middle of the clasper which is not shown in Barnes and Lindsey's figure. The length

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Figs. 6–7. 6, Female genitalia of *Oidaematophorus balanotes* (Meyrick), ventral view; 7, female genitalia of *Oidaematophorus lacteodactylus* (Chambers), ventral view. (Scale = 1 mm.)



Figs. 8-13. 8, Female genitalia of *Oidaematophorus glenni* Cashatt, n. sp., ventral view; 9-13, eighth abdominal tergite of female, dorsal view: 9, *Oidaematophorus balanotes* (Meyrick); 10, *Oidaematophorus grandis* (Fish); 11, *Oidaematophorus kellicottii* (Fish); 12, *Oidaematophorus lacteodactylus* (Chambers); 13, *Oidaematophorus glenni* Cashatt, n. sp. (Scale = 1 mm.)

and width of the valvae are highly variable, but the general shape and width of the clasper seem fairly constant.

McDunnough (1927) was unable to find Lindsey's slides or any specimens which resembled his illustration of the male genitalia. Therefore, he offered a new figure of the left valva (including the clasper) of a

species that he considered to be *O. lacteodactylus*. I have examined specimens whose genitalia are identical to McDunnough's figure, and I consider them to be new and distinct from *O. lacteodactylus*. This new species, *O. glenni*, is described below.

***Oidaematophorus glenni* Cashatt, new species**

(Figures 5, 8, 13; Map 1)

*Oidaematophorus lacteodactylus*: auctorum nec Chambers.

**Alar expanse:** 24–34 mm.

**Head:** Scale coloration identical to that of *O. balanotes*.

**Thorax:** Forewing brownish white with dark spot at base of cleft, or spot may be absent; ends of veins usually marked with dark or faded brown spots. Hindwing brownish white. Legs with scale coloration as in *O. balanotes*.

**Abdomen:** Scale coloration brownish white with indistinct pale brown longitudinal lines as in *O. balanotes*.

**Male genitalia** (Fig. 5): Similar to those of *O. balanotes* except clasper on left valva broadly curved, not attenuate, shorter and with tip flattened before terminating in a short, curved point.

**Female genitalia** (Figs. 8, 13): Similar to those of *O. balanotes* except anterior margin of tergite VIII with a narrow dorsal fold; anterior apophysis short and pointed, reinforced by lateral ends of dorsal fold.

**Type data:** Holotype, male, Putnam Co., Ill., June 12, 1953, M. O. Glenn, genitalia slide EDC 892; in the collection of the Illinois Natural History Survey. Paratypes (29 ♂♂, 21 ♀♀; Map 1): **California:** Big Trees, Santa Cruz Co., 1 ♂, July 19, 1921, Don Meadows, genitalia slide EDC 187 (USNM); Half Moon Bay, 1 ♀, June 14, 1937, W. H. Lange (USNM). **Colorado:** no locality, 2 ♀♀, Bruce, genitalia slides EDC 198, 272 (USNM). **Illinois:** Decatur, 1 ♂, no date, genitalia slide EDC 277 (USNM). All from Putnam Co.: 2 ♂♂, May 18, 1965, M. O. Glenn, genitalia slides EDC 894, 895 (MOG); 1 ♂, May 25, 1964, genitalia slide EDC 898 (MOG); 1 ♂, June 5, 1956, reared from larva in roots of *Solidago canadensis*, 11675 (USNM); 1 ♂, June 7, 1956, reared from larva in roots of *Solidago canadensis*, 11757, genitalia slide 190 (USNM); 1 ♂, June 9, 1955, larva reared on goldenrod (root borer), 11557, genitalia slide 191 (USNM); 1 ♂, June 9, 1956, larva reared from roots of *Solidago canadensis*, 11457, genitalia slide EDC 891 (MOG), 1 ♀, June 9, 1963, genitalia slide EDC 897 (MOG); 1 ♂, June 14, 1956 larva in roots of *Solidago canadensis*, genitalia slide EDC 900 (MOG); 1 ♀, June 14, 1967 (MOG); 1 ♂, June 16, 1956, larva in roots of *Solidago canadensis*, genitalia slide EDC 893 (MOG); 1 ♀, June 19, 1958, reared from larva boring in roots of goldenrod (MOG). **Iowa:** Homestead, 1 ♂, May 30, genitalia slide 72-448 (USNM). **Maryland:** All from Plummer's Island: 1 ♀, May 1, 1906, Aug. Busck, genitalia slide EDC 195; 1 ♂, June 5, W. V. Warner, genitalia slide EDC 204; 1 ♀, no date, Aug. Busck, genitalia slide EDC 197 (All USNM). **Massachusetts:** Barnstable, 1 ♂, June 20, 1954, C. P. Kimball, genitalia slide EDC 292 (CPK). **New Hampshire:** Hampton, 1 ♂, June 3, 1906, S. A. Shaw, genitalia slide 265 (USNM). **New Jersey:** Essex Co. Park, 1 ♂, June 24, trap, W. D. Kearfott, genitalia slide 72-447 (USNM). **New York:** Monroe Co., 1 ♂, June 10, 1947, C. P. Kimball, genitalia slide EDC 289 (CPK); same locality and collector, 1 ♂, June 27, 1948, genitalia slide EDC 291 (CPK); Newfield, 1 ♂, May 27, 1960, R. W. Hodges, genitalia slide EDC 906 (USNM); Six Mile Creek, Ithaca, 2 ♂♂, May 29, 1959, R. W. Hodges, genitalia slides EDC 905, 909 (USNM). **Pennsylvania:** Pittsburgh, 1 ♂, May 30, 1905, Henry Engel, genitalia slide EDC 203 (USNM). **Virginia:** Montgomery Co., 1 ♀, May 27, 1898, genitalia slide EDC 207 (USNM). **Washington:** All from Almota, reared from *Solidago* stalks by J. F. G. Clarke: 1 ♀, Jan. 3, 1935, genitalia

slide JFGC 396; 1 ♀, March 18, 1934, genitalia slide EDC 209; 1 ♂, March 21, 1934, genitalia slide EDC 178; 1 ♂, April 9, 1934, genitalia slide JFGC 397; 1 ♀, April 10, 1934, genitalia slide JFGC 394; 1 ♀, April 23, 1934, genitalia slide EDC 183; 1 ♂, May 3, 1935, genitalia slide EDC 181; 1 ♀, May 5, 1935, genitalia slide 391; 1 ♀, May 9, 1934, genitalia slide EDC 202; 1 ♀, May 13, 1935, genitalia slide JFGC 393; Wawawai, 2 ♂ ♂, 3 ♀ ♀, Jan. 9, 1935 reared from *Solidago* stalks, J. F. G. Clarke, genitalia slides EDC 179, 180, 182, 184 JFGC 395; same data 1 ♀, Jan. 10, 1935, genitalia slide 200 (All USNM). Wisconsin: Milwaukee Co., 2 ♂ ♂, March 3, 1923, F. P. Breakey, genitalia slides EDC 267, W. H. Lange 520.

**Food plant:** Dr. J. F. G. Clarke reared larvae which were boring in the stalks of *Solidago* sp. in Washington. Mr. Murray O. Glenn of Illinois collected and reared larvae from the roots of *Solidago canadensis* L.

I take great pleasure in naming this species after Mr. Murray O. Glenn, Henry, Illinois, who through many years of collecting has contributed much toward our knowledge of Lepidoptera in Illinois.

This species was considered to be *O. lacteodactylus* by McDunnough (1927). After examining genitalia slides which match the illustration of that species (Barnes and Lindsey 1921), I am convinced this species is distinct and separate from *O. lacteodactylus* and *O. kellicottii*. The clasper of the male genitalia of *O. glenni* has a flattened tip with a small oblique barb whereas the claspers of *O. lacteodactylus* and *O. kellicottii* have a finely drawn tip.

In addition to the localities listed in the type series, McDunnough (1927) reports the species to be widely distributed in Canada (Alberta, Manitoba, Ontario, Saskatchewan).

#### ACKNOWLEDGMENTS

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## ANNOTATED LIST OF THE BUTTERFLIES OF INDIANA, 1971

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and

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The entomologists at Purdue University, while having adequate funds available, necessarily concentrate their efforts and research on the insects considered agricultural pests. They are, however, building a world-wide collection of butterflies. At Indiana University funding for entomology is scarce and spent largely on teaching efforts. Thus the field of Rhopalocera has been wide open and challenging for the serious collector in Indiana, as was appreciated by the authors who received much encouragement and help from members of the Lepidopterists' Society. Although Indiana has had two major annotated state lists of Rhopalocera (Blatchley, 1891 and Montgomery, 1931), and more recently a list of the butterflies of Perry County (Masters and Masters, 1969), nearly forty years have passed without the publication of a comprehensive state-wide list of the butterflies (Papilionoidea) and skippers (Hesperioidae).

The State of Indiana, customarily considered a flat agricultural area, in reality combines a number of different and interesting zoogeographic regions with natural habitats for a diversified flora and fauna. In short

these are the northeastern lakes and bogs, the northeastern and central plains, the southeastern lowlands and flats, the south central hills, the Ohio-Wabash river lowlands, the intrusion of the prairie and the Kankakee sand area from Illinois, and the northwestern snow belt extending south and west of Lake Michigan and including the typical lake dune country. Thus Indiana provides a rich and varied collecting area for entomologists.

The authors, unknown to each other until 1968 and then only by correspondence, carried out intensive collecting in the north and central counties of Indiana at different periods which did not overlap. Both were challenged by the lack of up-to-date records and possibilities. They independently projected an annotated list of the Rhopalocera of the state with equal emphasis on the Papilionoidea and the more difficult Hesperioidea neglected either entirely or in part by Blatchley (1891), Montgomery (1931), and Masters and Masters (1969). This annotated list covers the officially recorded species. It combines the authors' individual efforts and draws freely on previously published papers, as well as information from collectors who have penetrated one or two counties deep from adjoining states. It also lists possible species not yet officially recorded for which the authors have diligently searched.

Shull collected sporadically in Indiana from 1932 to 1946, and regularly from 1964 to 1971. He collected intensively in Wabash and Kosciusko and frequently in Allen, Whitley, Huntington, Miami, Steuben, and LaGrange counties. His collection of more than 15,000 specimens contains 107 species. Badger collected from 1953 to 1962 intensively in Howard and Carroll counties and frequently in Fulton, Marshall, Pulaski, Marion, Brown and Lake counties. He collected 101 species with a total in excess of 10,000 specimens. The combined total of species collected is 118. Many other counties, particularly in the northern half of the state, were visited for desired species.

Portions of the state felt to have been inadequately covered are the central western prairie areas for the skippers surviving from the western prairies, the south central areas from Spring Mill State Park south including French Lick and the southwestern counties adjoining Kentucky and Ohio. The authors have only spot-checked these areas and intensive collecting in them should be rewarding. The southwestern counties have proved unrewarding, but on occasion yield southern species wandering northwards when conditions are favorable.

It is hoped that the following list will prove helpful to Indiana collectors and to others visiting and collecting in the state. A more thorough study of the indigenous and visiting species in many counties, especially in the southern parts, is greatly needed.



## HESPERIIDAE

- Panoquina ocola* (Edwards) **Ocola Skipper**. Uncommon locally in northeastern counties. Collected in August in Wabash and Kosciusko counties.
- Lerodea eufala* (Edwards) **Eufala Skipper**. Scattered late summer records in Perry County (Masters and Masters, 1969). Recorded in September, Kosciusko County.
- Amblyscirtes vialis* (Edwards) **Roadside Skipper**. Common in the southern half of the state, but rare or absent in the northern counties. From mid-May to early September.
- Atrytonopsis hianna* (Scudder) **Dusted Skipper**. Rare in Lake and LaGrange counties in June. Not taken in southern parts.
- Euphyes dion dion* (Edwards) **Dion Skipper**. Uncommon in the bogs of LaGrange, Wabash, Kosciusko, Fulton, and Marshall counties in late June and July.
- Euphyes dukesi* (Lindsey) **Dukes' Skipper**. Collected by Homer F. Price, July 24, 1962, Steuben County and by Shull, July 27, 1970, Wabash County.
- Euphyes conspicua* (Edwards) **Black Dash**. Uncommon to common in LaGrange, Steuben, Wabash, Marshall, Carroll, and Kosciusko counties in July.
- Euphyes bimacula* (Grote & Robinson) **Two Spotted Skipper**. Uncommon in boggy or marshy meadows, from late June to early September, in LaGrange, Wabash, Kosciusko, and Fulton counties.
- Euphyes vestris metacomet* (Harris) **Dun Skipper**. Common throughout the state, June to September.
- Poanes massasoit* (Scudder) **Mulberry Wing**. Uncommon to common in July in the northeastern bogs of LaGrange, Steuben, Wabash, and Kosciusko counties. Also found in Fulton and Marshall counties.
- Poanes hobomok* (Harris) **Hobomok Skipper**. Common in the northern half of the state from May to late August or early September. Diamorphic forms of the female *pocahontas* were found in Marshall, Howard, Cass, Marion, Fulton, and Kosciusko counties.
- Poanes zabulon* (Boisduval & LeConte) **Zabulon Skipper**. Apparently more common in the southern half of the state; however, it has been collected in Marshall, Howard, Cass, Marion, Fulton, and Kosciusko counties. May to September.
- Poanes viator* (Edwards) **Broad Winged Skipper**. Uncommon in the northeastern counties. July in Steuben and Wabash counties.
- Atryone delaware delaware* (Edwards) **Delaware Skipper**. Common throughout the state from late June to September.
- Atalopedes campestris* (Boisduval) **Sachem**. Common from late July to September in the northeastern counties. Scarce in late summer in Perry County, an extreme southern county (Masters and Masters, 1969).
- Pompeius verna verna* (Edwards) **Little Glassy Wing**. Common throughout the northern areas in June and July. September for Perry County.
- Wallengrenia otho egeremet* (Scudder) **Broken Dash**. Very common everywhere from June to mid-September.
- Polites coras* (Cramer) **Peck's Skipper**. Abundant over most of the state. May 24 to early October.
- Polites themistocles* (Latreille) **Tawny Edged Skipper**. Very common throughout the state. May 21 to October.
- Polites origines origines* (Fabricius) **Cross Line Skipper**. Fairly common some years in Kosciusko, Wabash, Howard, and Marion counties. From May 25 to early October.
- Politis mystic* (Scudder) **Long Dash**. Uncommon in LaGrange, Kosciusko, Wabash, Marshall, and Fulton counties in June.
- Hesperia metea* (Scudder) **Cobweb Skipper**. Found sparingly in southern Indiana in May.

- Hesperia sassacus* (Harris) **Indian Skipper**. Fairly common some years from late April to mid-June in Wabash and Kosciusko counties.
- Hesperia leonardus* (Harris) **Leonardus Skipper**. Usually uncommon in the northern half of the state, from July to September. Fewer records from southern counties.
- Hylephila phyleus* (Drury) **Fiery Skipper**. Uncommon throughout the state. From August 7 to September 21 in Wabash and Howard counties.
- Thymelicus lineola* (Ochsenheimer) **European Skipper**. Uncommon in June and July in Fulton, Wabash, and Kosciusko counties (Shull, 1968; Badger, unpublished, 1962). In recent years its numbers have increased and it should be looked for in other counties.
- Oarisma powesheik* (Parker) **Powesheik Skipper**. Uncommon locally in mid-June and July in the northwestern portions. Recorded in Lake County.
- Ancyloxypha numitor* (Fabricius) **Least Skipper**. Common from late May to early October in the northern half of the state. Sparse in southern counties.
- Lerema accius* (Abbott & Smith) **Clouded Skipper**. Status in the state is rather uncertain. Blatchley took it in Monroe County on July 3, 1886. New authentic records are needed to keep this species on the Indiana check list.
- Nastra therminier* (Latreille) **Swarthy Skipper**. Uncommon and local throughout most of the state. Masters and Masters (1969) found it not uncommon in Perry County in certain fields. Sometimes common in Brown County, but rare in Kosciusko County.
- Pholisora catullus* (Fabricius) **Common Sooty Wing**. Common throughout the state, from May 24 to September.
- Pyrgus communis communis* (Grote) **Checkered Skipper**. Common everywhere from August to early November.
- Erynnis icelus* (Scudder & Burgess) **Dreamy Dusky Wing**. Common in the northern half of the state in May and June. Not found in the southern counties.
- Erynnis brizo brizo* (Boisduval & LeConte) **Sleepy Dusky Wing**. Common from late April to June in the northern half; uncommon southward.
- Erynnis persius* (Scudder) **Persius Dusky Wing**. Collected by Badger, early May in the Dunes State Park, Lake County. Identified by Dr. J. M. Burns.
- Erynnis lucilius* (Scudder & Burgess) **Columbine Dusky Wing**. Not uncommon from late May to mid-June in LaGrange County. Blatchley (1891) found it in Putman and Lake counties.
- Erynnis baptisiae* (Forbes) **Wild Indigo Dusky Wing**. Shull collected a single specimen ♀ August 27, 1970 in Kosciusko County. Identified by Mr. H. A. Freeman.
- Erynnis zarucco* (Lucas) **Zarucco Dusky Wing**. One record from Crawfordsville by Fred T. Hall (1936).
- Erynnis martialis* (Scudder) **Mottled Dusky Wing**. Found locally throughout the state in June and July.
- Erynnis juvenalis juvenalis* (Fabricius) **Juvenal's Dusky Wing**. Common throughout the state from early May to June 5.
- Staphylus mazans hayhurstii* (Edwards) **Southern Sooty Wing**. Uncommon in Allen, Kosciusko, Wabash, Marshall, Fulton, Howard, and Marion counties. Found in May, June, and July.
- Thorybes bathyllus* (Smith) **Southern Cloudy Wing**. Fairly common throughout the state from mid-May to July.
- Thorybes pylades* (Scudder) **Northern Cloudy Wing**. Common throughout the state from mid-May to July.
- Achalarus lyciades* (Geyer) **Hoary Edge**. Uncommon in the northern counties in June and July. More common in Brown County and in the southern half of the state.
- Autochthon cellus* (Boisduval & LeConte) **Golden Banded Skipper**. Single specimen collected by Shull, June 7, 1971, Brown County State Park.
- Epargyreus clarus clarus* (Cramer) **Silver Spotted Skipper**. Common in the northern half of the state from May to September. Uncommon in the southern counties.

## PAPILIONIDAE

- Battus philenor philenor* (Linnaeus) **Pipe Vine Swallowtail**. Common throughout the state. May 1 to October 13 (late date).
- Papilio polyxenes asterius* (Stoll) **Black Swallowtail**. Most common swallowtail throughout the state. April 27 to October 20.
- Papilio cresphontes* (Cramer) **Giant Swallowtail**. Fairly common some years in the northern half of the state, usually in August. Found in June rarely and August in Kosciusko and Wabash counties. Masters and Masters (1969) refers to the Perry County subspecies as *pennsylvanicus* Chermock & Chermock (?).
- Papilio glaucus glaucus* (Linnaeus) **Tiger Swallowtail**. Common throughout the state from April 2 to October 2. In northern Indiana the yellow females are less numerous than the black females.
- Papilio troilus troilus* (Linnaeus) **Spicebush Swallowtail**. Common throughout the state. May 1 to October 13.
- Graphium marcellus* (Cramer) **Zebra Swallowtail**. Fairly common throughout the state from April to October 22.

## PIERIDAE

- Pieris protodice protodice* (Boisduval & LeConte) **Checkered White**. Widespread but not abundant throughout the state. April to October.
- Pieris napi oleracea* (Harris) **Mustard White**. Blatchley (1891) found it in Kosciusko County during the summer of 1890. On July 12, 1971 one specimen was collected in Mongo, LaGrange County by Shull.
- Pieris rapae* (Linnaeus) **European Cabbage Butterfly**. Very common throughout the state from late March to early November. In 1969 it had five broods in Kosciusko County (Shull's records). On June 17, 1969 a rare yellow female *rapae* was collected in Kosciusko County.
- Colias eurytheme eurytheme* (Boisduval) **Orange Sulphur; Alfalfa Butterfly**. Common throughout the state. May to November. On September 5, 1969 a typical orange ♀ *eurytheme* was in copula with a typical yellow ♂ *philodice* in an alfalfa field in Kosciusko County. This species and the next have many varied summer and winter forms.
- Colias philodice philodice* (Godart) **Common or Clouded Sulphur**. Very common in the whole state from mid-April to early November.
- Colias* (Zerene) *cesonia* (Stoll) **Dog Face**. Rare in the northern half of the state in September. Occasional records from the southern parts in September and October.
- Phoebis sennae eubule* (Linnaeus) **Cloudless Sulphur**. An uncommon local migrant into the southern counties. Rare in the north in the fall. Collected in Montgomery, Carroll, and Howard counties.
- Phoebis philea* (Johansson) **Orange Barred Sulphur**. Blatchley (1891) recorded a single specimen from Jefferson County collected by Mr. G. C. Hubbard. The only other record is by Cooper (1938) who raised an imago from a larva found in Shelby County. Klots (1951) includes Indiana in its range.
- Eurema lisa* (Boisduval & LeConte) **Little Sulphur**. Usually common throughout the state from June to October; however, some years it may be absent or uncommon.
- Eurema nicippe* (Cramer) **Sleepy Orange**. Uncommon in the northern half of the state from August to November. More common in late summer in the southern counties.
- Nathalis iole* (Boisduval) **Dainty Sulphur**. Locally common in many areas from late summer to the end of November.
- Anthocaris midea* (Hübner) **Falcate Orange Tip**. Not uncommon in central and southern Indiana from late April to early May. Some years it is rare or absent.
- Euchloe olympia olympia* (Edwards) **Olympia**. Not uncommon some years in the northern half of the state from mid-April to mid-May. Badger found it in Lake and Pulaski counties.

## RIODINIDAE

- Calephelis borealis* (Grote & Robinson) **Northern Metalmark**. Locally abundant in wooded areas during July in Montgomery, Brown, Howard, Marion, and Kosciusko counties.
- Calephelis muticum* (McAlpine) **Swamp Metalmark**. Usually uncommon in the northern bogs in July and August. Occasionally common in the tamarack bog at Mongo, LaGrange County.
- Harkenclenus titus* (Fabricius) **Coral Hairstreak**. Uncommon in the northern half of the state in June and July. Masters and Masters (1969) found the subspecies *mopsus* (Hübner) in Perry County in late June.
- Satyrium liparops strigosa* (Harris) **Striped Hairstreak**. Common in northeastern Indiana, and probably throughout the state, from late June to July 10.
- Satyrium calanus falacer* (Godart) **Banded Hairstreak**. Common throughout the state from late June to mid-July. Former Indiana records by the name *calanus* (Florida Hairstreak) belong to this classification.
- Satyrium caryaevorus* (McDunnough) **Hickory Hairstreak**. Uncommon in June and July in Kosciusko and Wabash counties.
- Satyrium edwardsii* (Saunders) **Edward's Hairstreak**. Uncommon in the northern half of the state in June and July.
- Satyrium acadica acadica* (Edwards) **Acadian Hairstreak**. Uncommon to locally common in LaGrange, Kosciusko, Wabash, Marshall, Fulton, and Lake counties in late June and early July.
- Calycopis cecrops* (Fabricius) **Red Banded Hairstreak**. Although both Blatchley (1891) and Klots (1951) list this species for Indiana, it must be rare indeed as we have not found it. Masters and Masters (1969) found it scarce in late May and July in Perry County.
- Callophrys (Incisalia) polios* (Cook & Watson) **Hoary Elfin**. Found in the sand dunes of Lake County in May. Uncommon in April in some southern counties.
- Callophrys (Incisalia) irus* (Godart) **Frosted Elfin**. Taken on lupine in May in Pulaski County. According to Ehrlich and Ehrlich (1961), it is found in northwestern Indiana.
- Callophrys (Incisalia) henrici turneri* (Clench) **Henry's Elfin**. Uncommon in April and May in the southern half of the state. Collected on redbud in Howard County.
- Callophrys (Mitoura) gryneus gryneus* (Hübner) **Olive Hairstreak**. Rare and local near Red Cedar during May in Carroll County. This species is probably widespread in southern Indiana. There are records from Lake and Parke counties.
- Atlides halesus* (Cramer) **Great Purple Hairstreak**. According to Ehrlich and Ehrlich (1961), strays have been taken in northern Indiana. The presence of mistletoe in Perry County makes it a likely area. We have not collected it in Indiana, but have taken it elsewhere.
- Euristrymon ontario* (Edwards) **Northern Hairstreak**. Some years it is uncommon from mid-June to early July in Wabash and Kosciusko counties. Dogbane is its favored food flower in northern Indiana.
- Panthiades m-album* (Boisduval & LeConte) **White M Hairstreak**. Strays have been found in southern Wisconsin, Ohio, and northern Indiana (Lake County). Masters and Masters (1969) report that Lois Ann Winter found a male of this species in Perry County between May 5 and 14, 1962. Badger found a stray in Carroll County, May 1960.
- Strymon melinus melinus* (Hübner) **Gray Hairstreak**. Some years it is common and other years uncommon in the northern half of the state from June 29 to October 3. Common in southern parts from April to September.
- Feniseca tarquinius tarquinius* (Fabricius) **Harvester**. Uncommon to rare in the southern half of the state. Found between mid-May and mid-September in Howard County.

- Lycaena thoe* (Guerin-Meneville) **Bronze Copper**. Fairly common in central and northern Indiana from June to early October. Uncommon in southern counties.
- Lycaena helloides* (Boisduval) **Purplish Copper**. Uncommon in July and August in Wabash and Kosciusko counties. Occasionally found in northwestern Indiana (Lake County).
- Lycaena dorcas* (Kirby) **Dorcas Copper**. Found rarely in the bogs of LaGrange County. We have not yet found it.
- Lycaena epixanthe* (Boisduval & LeConte) **Bog Copper**. Uncommon in July in Wabash County. Klots (1951) also records it in northern Indiana. Blatchley (1891) says it is rare in Lake County.
- Lycaena phlaeas americana* (Harris) **American Copper**. Common in the northern counties from May 15 to September 24. Rare in extreme southern portions. Badger found the form *fasciata* in Howard County.
- Lycaeides melissa samuelis* (Nabokov) **Karner Blue**. Uncommon to rare in LaGrange and Wabash counties; more common in Lake County. The northeastern populations formerly known as *scudderii* (Edwards) now belong to the races of *melissa*. Found from June to August.
- Everas comyntas comyntas* (Godart) **Eastern Tailed Blue**. Common throughout the state from April to early October.
- Glaucopsyche lygdamus* (Doubleday) **Silvery Blue**. Recorded from Wabash and LaGrange counties. Usually rare in May and June.
- Celastrina argiolus* (Linnaeus) **Spring Azure**. Abundant in northeastern Indiana, where most of the specimens belong to the subspecies *pseudargiolus* (Boisduval & LeConte) and its forms. The subspecies *lucia* (Kirby) does not occur in the northern portions of the state. *Argiolus* occurs throughout the state from mid-April to mid-September. Klots (1951) gives a fine description of this group.

## LIBYTHEIDAE

- Libytheana bachmanii* (Kirtland) **Snout Butterfly**. Usually common throughout the state from early April to September.

## NYMPHALIDAE

- Anaea andria andria* (Scudder) **Goatweed Butterfly**. Scattered records from the central and southern parts of the state in April, July, and August. Found in July in Orange County and in August in Wabash County.
- Asterocampa celtis celtis* (Boisduval & LeConte) **Hackberry Butterfly**. Common throughout the state, June 12 to September 4.
- Asterocampa clyton clyton* (Boisduval & LeConte) **Tawny Emperor**. Common in the entire state, but less so than the above species. From mid-June to September 14.
- Limenitis arthemis astyanax* (Fabricius) **Red Spotted Purple**. According to Platt and Brower (1968) *artemis* and *astyanax* are not distinct species. Therefore the present authors have combined them. Two specimens, having indistinct white bands, were collected June 21, 1969 in Wabash County. Rather prominent white-banded forms have been taken in a few northern counties. From June 5 to October 7 throughout the state, with the *astyanax* form greatly outnumbering the *artemis* form.
- Limenitis archippus archippus* (Cramer) **Viceroy or Mimic**. Common throughout the state. Early June to October 13.
- Vanessa atalanta* (Linnaeus) **Red Admiral**. Common throughout the state from late March to September 20. One very late date is October 26.
- Vanessa virginiensis* (Drury) **American Painted Lady**. Usually common throughout the state; however, some years it is uncommon or absent. From late April to September 25.
- Vanessa cardui* (Linnaeus) **Painted Lady**. Some years it is common to abundant

throughout the state; from March to September 20. In 1969, it was strangely absent in northern Indiana. It is a highly migratory species.

*Junonia coenia coenia* (Hübner) **Buckeye**. Usually common or fairly common and quite variable throughout the state; from May to October 13, and rarely to early November.

*Nymphalis vau-album j-album* (Boisduval & LeConte) **Compton Tortoise Shell**. Found in Porter and Lake counties. Two specimens were collected in August, 1934 in Wabash County. Rare.

*Nymphalis milberti milberti* (Godart) **Milbert's Tortoise Shell**. Very common in northern Indiana, but uncommon in the southern counties. From March to November 7. It may even hibernate as one was found on a log on December 29, 1953 in Madison County.

*Nymphalis antiopa antiopa* (Linnaeus) **Mourning Cloak**. Common throughout most of the state; less common in the south. From February to October 25.

*Polygonia interrogationis* (Fabricius) **Question Mark**. Common from March to November in the entire state.

*Polygonia comma* (Harris) **Comma** or **Hop Merchant**. Common throughout the state from March 4 to November 22; however, it may be rarely found much later on warm winter days.

*Polygonia satyrus* (Edwards) **Satyr Angle Wing**. Recorded from Kosciusko and Wabash counties from May 30 to late July. Uncommon, rare, or absent some years.

*Polygonia progne* (Cramer) **Gray Comma**. Common, uncommon, or absent some years in Wabash and Kosciusko counties. From June 20 to early November. Apparently uncommon in midsummer in several other counties.

*Chlosyne nycteis nycteis* (Doubleday) **Silvery Checkerspot**. Fairly common throughout the state from May 17 to mid-October.

*Chlosyne gorgone carlota* (Hübner) **Gorgone Checkerspot**. The only records are from Perry County by J. F. and Wilma L. Masters (1969). It should be looked for elsewhere.

*Chlosyne harrissi* (Scudder) **Harris' Checkerspot**. Our 1934 Wabash County records may be incorrect as they were not checked by an expert, but they are rarely taken from the Mongo tamarack bog in LaGrange County. Klots (1951) includes Indiana in its range.

*Phyciodes tharos tharos* (Drury) **Pearl Crescent**. Very common throughout the state from April or mid-May to October.

*Phyciodes batesi* (Reakirt) **Tawny Crescent**. Perhaps there are a few authentic records for Indiana from late May to early June, but upon close examination our *batesii* turned out to be aberrant *tharos*. As Masters and Masters (1969) suggest, this species may be widespread from Brown County northward.

*Euphydryas phaeton* (Drury) **Baltimore**. The nominate subspecies is uncommon in the northern half of the state in June and July. Specimens from Brown and other south-central counties, according to Masters and Masters (1969), may belong to the subspecies *ozarkae*, but ours from Brown County appear to be identical to the northern specimens.

*Boloria selene myrina* (Cramer) **Silver Bordered Fritillary**. Common in the far northern counties from June 15 to September. Absent in the remainder of the state.

*Boloria toddi ammiralis* (Hemming) **Meadow Fritillary**. Very common throughout the northern portions of the state from April 26 to October 1.

*Speyeria idalia* (Drury) **Regal Fritillary**. Scattered records from widely separated counties during July and August. Uncommon to rare in Wabash, Kosciusko, Marshall, and Fulton counties.

*Speyeria atlantis* (Edwards) **Atlantis Fritillary**. Blatchley (1891) and Montgomery (1931) both reported it from Vanderburgh and Lake counties. No authentic, recent records from any portion of the state have come to our attention. It should be found along the Indiana-Michigan border counties.



*Speyeria diana* (Cramer) **Diana**. Old records are from Vanderburgh County (Blatchley, 1891). According to Masters and Masters (1969), a male of this species was collected on July 15, 1962 just north of Troy in Perry County.

*Speyeria cybele cybele* (Fabricius) **Great Spangled Fritillary**. Common throughout the state. May 20 to September.

*Speyeria aphrodite* (Fabricius) **Aphrodite**. In northeastern Indiana most specimens belong to the subspecies *alcestis* (Edwards). Some years it is common from June 25 to late August. A few nominate subspecies have been collected in the extreme northern bogs. Also the aphrodite was found in Marshall, Fulton, and Howard counties.

*Euptoieta claudia claudia* (Cramer) **Variegated Fritillary**. Uncommon throughout the state, but more found in the northeastern counties of LaGrange, Kosciusko, and Wabash. From June 22 (early) to October 15.

*Agraulis vanillae* (Linnaeus) **Gulf Fritillary**. Blatchley (1891) reported it from Vanderburgh County. Lawrence James collected one in Clay County in July.

#### DANAIDAE

*Danaus plexippus plexippus* (Linnaeus) **Monarch**. Some years common throughout the state; normally from late April to early November, but more common in September, when occasional southward migrations take place.

#### SATYRIDAE

*Lethe portlandia anthedon* (Clark) **Pearly Eye**. Uncommon throughout the state. Occasional records from Howard and Carroll counties. June to August.

*Lethe creola* (Skinner) **Creole Pearly Eye**. Extremely rare in northeastern Indiana near the Michigan border. Masters and Masters (1969) report that Dr. E. M. Brackney took one on June 29, 1965 in Orange County.

*Lethe eurydice appalachia* (R. L. Chermock) **Eyed Brown**. Uncommon to common in the northeastern counties from June to August. Found in LaGrange, Steuben, Wabash, and Marshall counties. Less common in the central portions of the state.

*Euptychia gemma gemma* (Hübner) **Gemmed Satyr**. Recorded only in Perry County from late April to early October by J. H. and Wilma L. Masters.

*Euptychia mitchellii* (French) **Mitchell's Satyr**. Uncommon in July in our extreme northeastern county bogs. Collected in LaGrange County many years by Homer F. Price.

*Euptychia cymela cymela* (Cramer) **Little Wood Satyr**. Very common throughout the state from late May through July.

*Cercyonis pegala* (Fabricius) **Wood Nymph, Grayling**. Common in the northern half of the state, but absent in the southern parts. From mid-May to October 1. The subspecies *nephele* (Kirby) is occasionally found in July from Kosciusko County, but *C. p. alope* (Fabricius) is the common form in Wabash and Kosciusko counties. Other subspecies seem to be present, but they may be only aberrant forms. This species, with its many overlapping or integrated forms, needs far more study in Indiana.

#### HYPOTHETICAL LIST FOR INDIANA

Collectors should look for the following species in Indiana:

#### Hesperiidae

*Amblyscirtas samoset* (Scudder). Mississippi Valley.

*Atrytone arogos* (Boisduval & LeConte). Florida and Gulf States, north to New Jersey, Minnesota, Iowa, and Nebraska.

- Polites vibex* (Geyer). Tropics north to Connecticut, Arkansas, and a dubious Wisconsin record.  
*Hesperia uncas* (Edwards). A western prairie species which sometimes enters the eastern area.  
*Hesperia attalus* (Edwards). Ohio and Wisconsin.  
*Pyrgus centaureae* (Rambur). New York to Colorado.  
*Erynnis horatius* (Scudder & Burgess). Ohio.  
*Thorybes confusus* (Bell). Missouri, Maryland. Probable ♀ June 17, 1962, Marshall County—Badger.

## Pieridae

- Ascia monuste* (Linnaeus). Mississippi Valley to Kansas.  
*Colias interior* (Scudder). Michigan.  
*Phoebis agarithe* (Boisduval). Strays to Illinois.  
*Eurema mexicana* (Boisduval). Rarely to Michigan and Wisconsin.  
*Kricogenia lyside* (Godart). Strays to Illinois.

## Lycaenidae

- Callophrys (Incisalia) augustinus* (Westwood). Illinois and Michigan.  
*Callophrys (Incisalia) niphon* (Hübner). Michigan.  
*Satyrium kingi* (Klots & Clench). Harry K. Clench has written that it seems to occupy the same habitat as *Lethe creola*.  
*Lycaena xanthoides* (Boisduval). Upper Mississippi Valley, Kansas north through Nebraska, Minnesota, and Illinois.  
*Plebejus saepiolus* (Boisduval). Michigan.

## Riodinidae

- Lephelisca virginiensis* (Guérin-Ménéville). Ohio.

## Nymphalidae

- Polygonia faunus* (Edwards). Canada to South Carolina, Iowa, and Michigan.  
*Boloria eunomia* (Esper). Michigan and Wisconsin.

## ACKNOWLEDGMENTS

In this annotated list of Indiana butterflies, the authors have, in the main, followed the classificatory arrangement of Dr. Cyril F. dos Passos, *A Synonymic List of the Nearctic Rhopalocera* (1964), and his revisions of the Nearctic Melitacinae (1969) and the Nearctic Lycaenidae (1970).

*A Guide to the Butterflies* (1951) by Dr. Alexander Klots, *The Butterfly Book* (1940) by Dr. J. W. Holland, and *How to Know the Butterflies* (1961) by Dr. and Mrs. Paul R. Ehrlich constitute the primary sources used for identification; however, a few of the more difficult species and subspecies were either confirmed or identified by the following experts: Dr. J. M. Burns of Cambridge, Mass., Mr. Harry K. Clench of the Carnegie Museum, Pittsburgh, Pa., Mr. H. A. Freeman of Garland, Texas, and Drs. Frederick H. Rindge and Alexander B. Klots of the American Museum of

Natural History, New York. To these people the authors are greatly indebted. The authors, of course, assume full responsibility for any inaccuracies which may have been reported in this study.

Correspondence with the following collectors has been very helpful in determining the distribution of some species: Mr. Ray W. Bracher of Granger, Ind., Dr. J. W. Burns of Cambridge, Mass., Mr. Harry K. Clench of Pittsburgh, Pa., Mr. Julian P. Donahue and Mr. M. C. Nielsen of East Lansing, Mich., Dr. Richard Heitzman of Independence, Mo., Dr. R. R. Irwin of Chicago, Ill., Dr. Wilbur S. McAlpine of Union Lake, Mich., Mr. Homer F. Price of Payne, Ohio, Dr. Charles Remington of New Haven, Conn., Dr. P. Sheldon Remington of Greenwich, Conn., and Mr. James E. Shields of Indianapolis, Ind.

Also appreciation is expressed to the coordinators and reporters of the Annual Summary reports, published by the Lepidopterists' Society, formerly in the *Journal* and recently in the *News*.

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## THE LIFE HISTORY OF *SCHINIA INTRABILIS* (NOCTUIDAE)

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*Schinia intrabilis* Smith (1893, p. 331) feeds in the larval stage on the blossoms of the Arrowweed, *Pluchea sericea* (Nutt.) Cov. The arrowweed is a willow-like composite that occurs abundantly around seeps and along river banks in the deserts of southern California. During the early blossoming period of its food plant, *Schinia intrabilis* is not a rare insect in appropriate desert habitats.

According to Munz (1963), the Arrowweed is distributed from southern California eastward to Texas, but I have examined *intrabilis* only from as far east as Yuma and Ehrenberg, Arizona. The species is univoltine and the period of adult activity is co-ordinated in any area with the single annual blossoming period of the Arrowweed. Specimens in the Canadian National Collection from the deserts of southern California were taken on dates between the middle of March and the end of April.

### Behaviour

*Schinia intrabilis* is evidently a species of exclusively or preponderantly nocturnal habits. In moist areas in which eggs and young larvae could be recovered without difficulty from Arrowweed heads, no adult activity was noted during daylight hours.

Eggs are deposited in the Arrowweed head at a stage when the sepals of the bud have drawn apart at the top sufficiently to expose the florets. Females do not and probably cannot oviposit in the tough, leathery, unopened buds. The egg is inserted among the florets from the top of the head.

Three captive females deposited a mean of 83 eggs, and the maximum



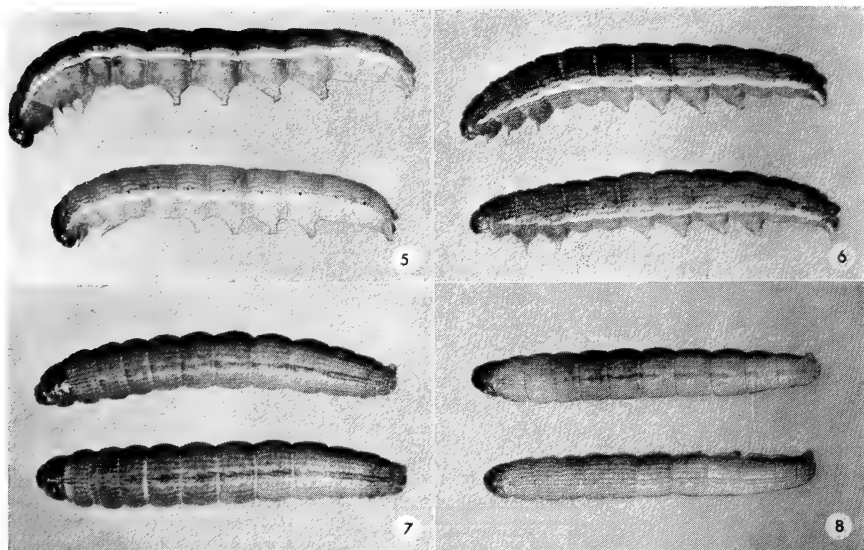
Figs. 1-4. *Schinia intrabilis* Smith, its habitat and food plant. 1, Adult, Twenty-nine Palms, Calif. 2, Willis Palms, near Indio, Calif. 3, 4, *Pluchea sericea* (Nutt.) Cov.

deposited by a single female was 132. Eggs maintained at room temperature hatched on the third and fourth days after deposition.

The newly hatched larva bores into an adjacent floret and tunnels down through it toward the receptacle. The second and subsequent instars feed preponderantly on the developing seeds. Usually by the third stadium, the larva quits the first head and enters a second. Both third- and fourth-stadium larvae attack the heads from the top, and the half grown larvae must curl up within the individual head to remain concealed while feeding. Toward the end of the fourth stadium and during the fifth, the larva feeds on the heads from a position on the stem; it usually attacks the head by boring a hole through the side just above the heavy sepals that surround the base. At the cessation of feeding the larva makes its way to the surface of the ground and tunnels into the soil to pupate.

#### Descriptions of Stages

The following descriptions of immature stages were based on the progeny of seven females taken in the Indio area of southern California. The



Figs. 5-8. *Schinia intrabilis* Smith, ultimate-stadium larvae. 5, 6, Left lateral; 7, 8, dorsal.

durations of stadia listed are those obtained from rearings maintained at room temperature. Rearing techniques employed were the same as those outlined by Hardwick (1958). The estimate of variation, following the means for various values, is the standard deviation.

**Adult** (Fig. 1). Head and thorax light olivaceous fawn. Abdomen paler, cream or creamy-grey. Forewing fawn or fawn-grey, often with an olivaceous suffusion. Transverse anterior line white, angling outward from trailing margin, then curving sharply inward and terminating not on costal margin but at base of wing. Basal space fawn or fawn-grey. Transverse posterior line white, angling inward from costa near apex to a point below reniform spot then curving outwardly to meet trailing margin near outer angle. Median space variably suffused with white or pale grey and thus usually paler than basal and subterminal spaces. Orbicular and claviform spots absent; reniform evident as a dark, ill-defined shade. Subterminal line cream, regular, close to outer margin of wing and parallel to it. Fringe and narrow terminal space concolorous with subterminal space. *Hind wing* white with a brown outer-marginal band and a large brown discal spot; a pale median streak in outer-marginal band. Inner margin of wing often suffused with brown. Fringe white with a yellowish or brownish basal line. *Underside* of forewing shining cream with a large dark-brown reniform spot and a light-brown submarginal band. Hind wing white, with or without brown spots on disc and near anal angle.

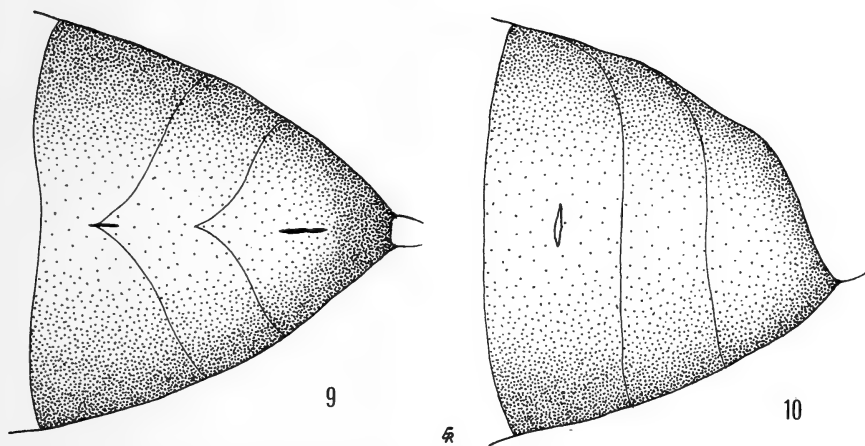
*Expanse*:  $23.5 \pm 1.3$  mm (47 specimens).

**Egg.** Very pale yellow when deposited, and exhibiting little colour change until a few hours before hatching when head capsule becomes visible through chorion.

*Dimensions of egg*: length,  $0.872 \pm 0.025$  mm; diameter,  $0.510 \pm 0.042$  mm (25 eggs).

*Incubation period*:  $3.5 \pm 0.5$  days (104 eggs).

**First-Stadium Larva.** Head medium to dark smoky-brown. Prothoracic and suranal



Figs. 9, 10. *Schinia intrabilis* Smith, apical abdominal segments of pupa. 9, Ventral; 10, right lateral.

shields concolorous with head or somewhat paler. Trunk white, cream, or pale grey. Spiracles with light- to medium-brown rims. Legs medium smoky-brown.

*Head width:*  $0.262 \pm 0.009$  mm (15 larvae).

*Duration of stadium:*  $3.7 \pm 0.9$  days (33 larvae).

**Second-Stadium Larva.** Head light orange-brown, mottled dorsally with light to medium smoky-brown. Prothoracic shield fawn to light orange-brown, variably mottled and emarginated with chocolate-brown. Suranal shield approximating prothoracic shield in colour and similarly marked with brown. Trunk light greyish-cream to pale greenish-grey, usually with two pairs of dorsal and a pair of lateral white lines. Spiracles with dark-brown rims. Thoracic legs fawn to light orange-brown, variably suffused with smoky-brown.

*Head width:*  $0.446 \pm 0.034$  mm (25 larvae).

*Duration of stadium:*  $3.0 \pm 0.8$  days (33 larvae).

**Third-Stadium Larva.** Head warm cream mottled dorsally with light orange. Prothoracic shield fawn, mottled with white and brown and with a white median line. Suranal shield white, lightly mottled with pale brown. Trunk green with numerous longitudinal white lines. Mid-dorsal band light greyish-green, often with a white median line. Subdorsal area consisting of white marginal lines and a median greyish-green band; median band often with a diffuse white median line. Supraspiracular area greyish-green with a white median line. Spiracular band white. Ventral region light grey. Rims of spiracles and bases of setae dark brown or black. Thoracic legs pale fawn suffused with light smoky-brown.

*Head width:*  $0.70 \pm 0.03$  mm (18 larvae).

*Duration of stadium:*  $3.3 \pm 0.7$  days (33 larvae).

**Fourth-Stadium Larva.** Head cream, mottled dorsally with very pale fawn. Prothoracic shield light green with three longitudinal white lines. Suranal shield light green or light fawn variably marked with cream. Trunk greenish-grey at beginning of stadium, becoming leaf-green after feeding; trunk with numerous longitudinal lines of cream or pale grey. Mid-dorsal band green with a median longitudinal shade of cream or pale grey. Subdorsal area cream or pale grey with a pair of median longitudinal green lines. Supraspiracular area cream or pale grey margined by green lines and with a pair of green median lines. Spiracular band white with a discontinuous green median shade. Suprapodal area green, mottled with cream and lightly marked

with fawn. Mid-ventral area greyish-green. Spiracles with black rims. Thoracic legs straw-coloured, often tinged with green proximally, and occasionally lightly suffused with fawn.

*Head width:*  $1.10 \pm 0.03$  mm (25 larvae).

*Duration of stadium:*  $4.0 \pm 0.6$  days (33 larvae).

**Fifth-Stadium Larva** (Figs. 5–8). Larvae occurring in two colour phases, pale fawn and green. Head straw-coloured, faintly mottled with orange, and suffused with green in green specimens. Prothoracic shield pale orange or pale green; three narrow white longitudinal lines usually evident; shield marked with black around bases of setae. Suranal shield pale fawn or green, marked with white and with black setal bases. Trunk pale fawn or light green. Mid-dorsal band somewhat darker than remainder of dorsum. Subdorsal and supraspiracular areas undistinguished, mauve-grey with six or seven longitudinal lines of pale fawn or bright green; longitudinal lines often irregular and discontinuous. Spiracular band white with a median shade of fawn or green. Suprapodal area pale fawn or green, lightly marked with mauve-grey. Mid-ventral area pallid fawn or pale green. Thoracic legs pale fawn, suffused with green in green specimens.

*Head width:*  $1.75 \pm 0.08$  mm (7 larvae).

*Duration of stadium:*  $5.4 \pm 1.1$  days (33 larvae).

**Pupa** (Figs. 9, 10). Medium orange-brown, the appendages often suffused with green. Spiracles on a level with general surface of cuticle; spiracular sclerites weakly projecting. Anterior marginal areas of abdominal segments 5, 6 and 7, each with a rather wide band of prominent pitting. Proboscis terminating well anterior to apexes of wings. Apex of tenth abdominal segment broadly rounded and bearing two short, fine setae.

*Length from anterior end to posterior margin of fourth abdominal segment:*  $8.1 \pm 0.4$  mm (23 pupae).

#### ACKNOWLEDGMENTS

I appreciate the help of my associate, Mr. Eric Rockburne, who measured the immature stages and drew the cremaster area of the pupa. Mr. John E. H. Martin of the Entomology Research Institute took the photographs accompanying this paper.

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#### NATURAL INTER-BREEDING OF CLOSE NYMPHALID GROUPS

On June 12, 1971 on the hilltops of Mother Cabrini Shrine in Jefferson County, Colorado, a freshly emerged female of *Melitaea pola arachne* Edwards was found in copulation with a male *Chlosyne gorgone carlota* Reakirt. The male was hanging and the female was flying. The time was 0920 and the legend was Joel Jablonski.

RAYMOND J. JAE, 1286 South Umatilla St., Denver, Colorado 80223.



## THE LIFE HISTORY OF *SCHINIA PALLICINCTA* (NOCTUIDAE)

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*Schinia pallicincta* Smith (1906, p. 24) feeds in the larval stage on the heads of Desert Marigolds, *Baileya pauciradiata* Harv. and Gray and *B. multiradiata* Harv. and Gray. All specimens of *pallicincta* in the Canadian National Collection were taken on the California deserts in areas between Ocotillo, San Diego Co. and Mono Lake, on dates between the middle of March and the first of June.

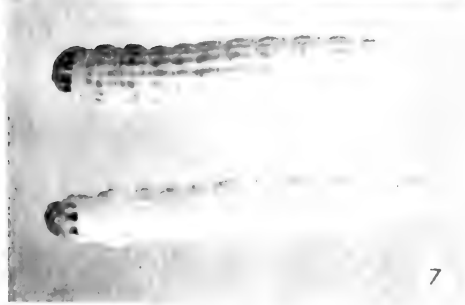
The species is obviously closely related to *Schinia miniana* (Grote, 1881, p. 175) which was described from New Mexico. The latter species is larger and more brightly coloured, however, and the hind wings are rosy red rather than smoky brown. Two specimens of *miniana* in the Canadian National Collection from the Big Bend area of western Texas were taken in the heads of *Baileya multiradiata*. It is possible that *pallicincta* and *miniana* represent only well-defined races of a single species. Life history data on *miniana*, and a study of series of specimens from intermediate localities will undoubtedly elucidate the situation.

### Behaviour

The full globular eyes of *Schinia pallicincta* suggest that the species is primarily nocturnal, and indeed it is often taken at light; however, it is also frequently found during the hours of daylight flying among clumps of its food or ovipositing in the heads. The eggs are deposited in both the buds and blossoms, but those buds which have opened sufficiently to expose the upper ends of the still tightly closed florets are greatly preferred to smaller buds or open heads. The eggs are inserted among the florets.

Five captive females deposited a mean of 40.3 eggs, and the maximum deposited by a single individual was 74. The majority of eggs hatched on the sixth day after deposition.

The newly hatched larva bores into an adjacent floret and feeds on the contents. In the early stadia, the larva tunnels within the florets. In the median stadia the larva feeds on both seeds and florets, and in the ultimate stadium, the whole contents of the receptacle except for the ray florets are consumed. When feeding in the heads of *Baileya multiradiata*, the inner ray petals are drawn together by the late-stadium larva to form



a nest in which it remains concealed; the habit was never noted among larvae feeding in the heads of *Baileya pauciradiata*.

On the completion of feeding, the larva makes its way to the ground and tunnels into the soil to pupate. When the larva tunnels into the sandy soil characteristic of the dunes areas in which *Baileya pauciradiata* is abundant it forms a delicate silken tube leading down to the pupal cell. Evidence of this tube could not be found in cases in which larvae pupated in heavier soil.

### Descriptions of Stages

The following descriptions of immature stages were based on the progeny of five females taken in the sand dunes area west of Indio, California. The specimens were taken flying about or resting on the heads of *Baileya pauciradiata*. The larvae were reared individually at room temperature on the heads of *B. pauciradiata*. Rearing techniques employed were those described by Hardwick (1958). The estimate of variability following the means for various values is the standard deviation.

**Adult** (Figs. 1, 3). Head and thorax varying from bright yellow to light fawn. Abdomen usually paler than thorax and with a greyish tone. Forewing light fawn marked with white. Transverse anterior line broad, white, straight or weakly excurved. Basal space pale fawn, suffused with yellow in specimens with yellow vestiture on thorax. Transverse posterior line broad, white, weakly excurved around cell, then essentially straight to inner margin. Median space pale fawn, rarely with a brown median shade. Orbicular and reniform spots not defined. Subterminal line usually indicated only as an elongate dark mark at costal margin. Fused terminal and subterminal spaces concolorous with median space. Fringe fawn, usually checkered with darker scaling. *Hind wing* dark smoky-brown, usually becoming paler toward base, and rarely with a pink iridescence. Fringe cream, often with a yellow basal line. *Underside* of forewing light fawn, usually heavily overlaid with brown through central area; central brown area often tinged with pink marginally; fringe pale fawn. *Hind wing* pale fawn, variably marked with brown, or pink and brown, in basal and median areas; fringe fawn.

**Expanse:**  $19.1 \pm 0.9$  mm (16 specimens).

**Egg.** Very pale yellow when deposited and remaining essentially unchanged until a few hours before hatching when head capsule becoming visible through chorion.

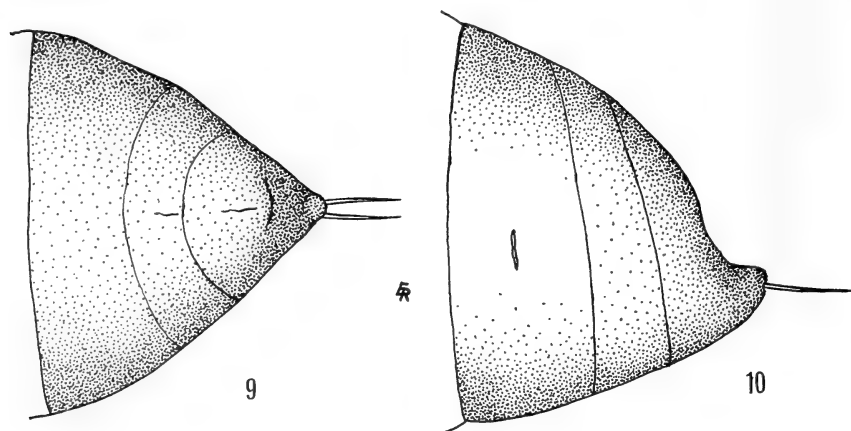
**Dimensions of egg:** length,  $0.784 \pm 0.040$  mm; diameter,  $0.361 \pm 0.010$  mm (5 eggs).

**Incubation period:**  $6.1 \pm 0.3$  days (121 eggs).

**First-Stadium Larva.** Head blackish-brown. Prothoracic and suranal shields dark smoky-brown. Trunk pale yellow or cream. Spiracles with light- to medium-brown rims. Thoracic legs dark smoky-brown.

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Figs. 1-8. *Schinia pallicincta* Sm. and its food plant. 1, Adult, La Quinta, Riverside Co., Calif. 2, pupae; 3, adult resting in sunflower head; 4, food plant, *Baileya pauciradiata* Haw. and Gray; 5, 6, left lateral aspect of ultimate-stadium larvae; 7, 8, dorsal aspect of ultimate-stadium larvae.



Figs. 9, 10. Apical abdominal segments of pupae. 9, Ventral; 10, right lateral.

*Head width:*  $0.259 \pm 0.004$  mm (20 larvae).

*Duration of stadium:*  $3.4 \pm 0.8$  days (40 larvae).

**Second-Stadium Larva.** Head dark chocolate-brown or black. Prothoracic shield medium to dark smoky-brown, often with a cream or pale-grey median line. Suranal shield medium smoky-brown. Trunk cream or creamy-grey, often with a median dorsal, and a pair of subdorsal light yellow lines. Spiracles with medium-brown rims. Thoracic legs dark smoky-brown.

*Head width:*  $0.454 \pm 0.042$  mm (20 larvae).

*Duration of stadium:*  $2.5 \pm 0.8$  days (40 larvae).

**Third-Stadium Larva.** Head dark chocolate-brown or black. Prothoracic shield medium to dark chocolate-brown, usually with a median and a pair of submarginal greyish-yellow longitudinal lines. Suranal shield medium to dark smoky-brown, often with three pale yellowish-grey longitudinal lines. Maculation of trunk usually poorly defined. Mid-dorsal band greyish-yellow. Subdorsal area paler than mid-dorsal band, often with a darker median shade. Supraspiracular area greyish-yellow, margined ventrally by a cream line. Spiracular band light yellow. Ventral region yellowish-grey. Spiracles with medium-brown rims.

*Head width:*  $0.656 \pm 0.053$  mm (25 larvae).

*Duration of stadium:*  $2.2 \pm 0.8$  days (40 larvae).

**Fourth-Stadium Larva.** Head varying from medium chocolate-brown through dark brown to black; dark mottling usually evident on lighter heads. Prothoracic shield medium to dark smoky-brown, with three longitudinal lines of pale yellow or grey. Suranal shield light to medium smoky-brown, commonly with three pale longitudinal lines. Mid-dorsal band pale yellow, yellowish-grey, or greenish-grey. Subdorsal area with a median band somewhat paler than mid-dorsal band, and marginal lines of pallid yellow. Supraspiracular area concolorous with median band of subdorsal area, with a median line of pale yellow. Spiracular band pale yellow or cream. Ventral region pale yellowish-grey. Spiracles with medium- to dark-brown rims. Thoracic legs light to dark smoky-brown.

*Head width:*  $1.16 \pm 0.07$  mm (20 larvae).

*Duration of stadium:*  $2.6 \pm 0.8$  days (40 larvae).

**Fifth-Stadium Larva** (Figs. 5-8). Head shades of orange-brown, suffused and mottled with darker brown. Prothoracic shield varying from pale fawn marked with brown to uniform dark blackish-brown; shield with three longitudinal lines of pale

yellow. Suranal shield paler than prothoracic shield, with three longitudinal, cream or pale-yellow lines. Mid-dorsal band varying from pale yellow-fawn to dark smoky-brown. Subdorsal area consisting of a median band concolorous with or somewhat paler than mid-dorsal band, and marginal lines of pale yellow. Supraspiracular area concolorous with median band of subdorsal area. Spiracular band pale yellow, cream or sometimes almost white; often a pale smoky-brown line through middle of spiracular band. Suprapodal area pale-yellow or pale greyish-yellow. Mid-ventral area usually paler than suprapodal area. Spiracles with dark-brown or black rims. Thoracic legs varying from dull yellow to orange-brown, variably suffused with dark smoky-brown.

*Head width:*  $1.72 \pm 0.11$  mm (23 larvae).

*Duration of stadium:*  $5.1 \pm 1.2$  days (40 larvae).

**Pupa** (Figs. 2, 9, 10). Spiracles borne in shallow depressions of the cuticle. Spiracular sclerites narrow. Anterior marginal areas of abdominal segments 5, 6 and 7 conspicuously pitted. Proboscis terminating at or slightly anterior to apexes of wings. Cremaster consisting of two rather short setae borne on a peculiarly shaped prolongation of the tenth abdominal segment; prolongation of the tenth segment truncated in profile and usually flattened on the ventral surface.

*Length from anterior end to posterior margin of fourth abdominal segment:*  $6.17 \pm 0.39$  mm (25 pupae).

#### ACKNOWLEDGMENTS

I am grateful to Mr. John E. H. Martin of this Institute for the photographs accompanying this paper, and to my associate Mr. Eric Rockburne for measuring larval structures and drawing the cremaster area of the pupa.

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#### PROTECTIVE FUNCTION OF SOUND PERCEPTION AND GREGARIOUSNESS IN *HYLESIA* LARVAE (SATURNIIDAE: HEMILEUCINAE)

While in residence at the Tropical Science Center field station on the Osa Peninsula of Costa Rica (1.8 miles west of Rincon), I was able to make some observations on a colony of *Hylesia* larvae which suggested a very probable function for their gregarious behavior and ability to perceive sound.

I first discovered a large aggregation of these larvae (approximately 330 individuals) in an oval mass on the trunk of a medium-sized tree, *Trema micrantha* (Linnaeus), on 3 April 1971. The mass was located on the north side of the tree about 1 m above the ground and was about 60 cm in length vertically and 18 cm in width. I accidentally became aware of the ability of the larvae to perceive sound when I shouted in their direction from a distance of about 10 meters. I was amazed to see the entire surface of the mass "jump." Each of the larvae responded to the sound of my voice

at the same instant and in the same manner, a violent jerking of the anterior third of the body, so that the head, thorax and anterior portion of the abdomen were arched upward or sideward.

I tested this reaction numerous times and ways by altering the pitch and loudness of my voice and determined to my satisfaction that the action was due to sound and not to air movement. The larvae reacted only to very sharp and relatively high pitched sounds of high intensity. Normal conversation did not cause any movement. I further tested the response by playing music (Strauss waltzes) from a tape recorder in the immediate vicinity of the mass (within 1 meter) and noted that the larvae responded in the same manner to loud, sharp portions of the music.

I observed the mass for 5 days. Each day I noted fewer individuals until the 8th of April, at which time there were no longer any present. Several larvae at the beginning had freshly molted, apparently transforming from the penultimate to the final instar. On several occasions during the day, larvae were seen on the ground crawling away from the tree, apparently in search of pupation sites or possibly food. The mass was present on the tree trunk only during the day, migrating at night to another place which was never determined.

This jerking behavior of gregarious lepidopterous larvae in response to sound has been observed and recorded by only a few authors. Minnich (1936, *J. Exper. Zool.* 72: 439-453) studied the reaction in the larvae of *Nymphalis antiopa* and records several other species of Lepidoptera which have been noted to behave similarly. None of these accounts, however, offers an explanation for the function of the behavior. Some additional observations which I made on this occasion suggested to me that sound perception coupled with the massing of these larvae served as a protection from parasites.

The larvae were being parasitized by two species, a yellow and black chalcidine wasp and a tachinid fly. The former, on approaching the mass and hovering over it prior to landing and oviposition, elicited the jerking movement. The anterior portions of the caterpillars being thrown dorsally had the effect of warding or fending off the approaching wasps. The denseness of the hairs of the richly branched scoli furnished a barrier to the penetration of the parasites. The larvae in the center of the mass were especially well protected since their flanks were not vulnerable to lateral attacks. The tachinid flies did attempt to approach the larvae from the side by crawling along the bark but were warded off in a similar fashion by lateral jerking. When approaching the mass from above, these flies also elicited the dorsal arching. The high pitched whining of the wings of the approaching or hovering parasite seemed to be of the correct quality and intensity to elicit the jerking response. The effectiveness of this defensive maneuver is enhanced by the fact that the larvae are densely grouped and heavily clothed with spines and hairs. This behavior would offer much less protection to individual larvae than to larvae en masse.

This protective behavior was not completely successful, however. I observed oviposition by the chalcidine wasps numerous times. Still, the attacking females experienced great difficulty in gaining access to the host's skin through the hair and spine network and violent defensive movements of the mass.

The spines of the scoli are highly urticating to human skin and may also function more effectively in inhibiting attacks from vertebrates by being forced into the skin through this same jerking motion.

A cinematographic record of these observations is on file with Alan Landsburg Productions, Hollywood, California (Production 1106-02, rolls 157, 158 and 166a). My thanks are extended to that organization for the opportunity to be in the study area and to Julian P. Donahue for assistance in identifying the caterpillars. Unfortunately it was impossible to determine the species of *Hylesia*; several are common at the site.

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STUDIES ON THE CATOCALA (NOCTUIDAE)  
OF SOUTHERN NEW ENGLAND  
II. COMPARISON OF COLLECTING PROCEDURES

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Adult nocturnal Lepidoptera are collected by several very different methods. Brower (1947) has described some of the more common methods—baits (unless indicated otherwise, “baits” in this paper refer to some kind of sugar mixture) and lights during the night, and hunting resting moths during the day. Each of these collecting methods has been modified so that numerous light traps, bait mixtures, etc. are used. Recently parabolic moth sheets (McFarland, 1966) and collapsible bait traps (Platt, 1969) have been added to the list of collecting methods from which lepidopterists can choose. With growing interest and knowledge in insect pheromones, many entomologists are now using traps baited with virgin females or synthetic sex pheromones (e.g. Saario, Shorey & Gaston, 1970). Considered together with differences in time of collecting and differences in ecological placement of the trap, collecting procedures are widely divergent.

How do these various collecting procedures compare when sampling the same area? Hamilton and Steiner (1939) and Robinson and Robinson (1950) have previously compared various trapping methods as to effectiveness of capture. The former, interested in controlling the Codling Moth (*Carpocapsa pomonella* (Linnaeus)), a noctuid pest of orchards, compared bait and light traps and found that light traps captured more moths per trap, but that the percentage of females was much smaller than in the bait traps. The Robinsons have compared various light sources and suggest that the spectral content of the light is not important within limits, although the power and surface brightness of the source does affect trap efficiency. Others report that the kind of light (mercury, tungsten, etc.) determines not only the species attracted, but also the sex (Edwards, 1962).

The importance of a trap's location in sampling populations has also been noted. Hamilton and Steiner (1939) found that traps located at the margin (border rows) of an orchard averaged more than twice the number of moths per trap than those located in the interior. Holbrook, Beroza and Burgess (1960) reported differences in effectiveness of pheromone-baited traps (Gypsy Moth—*Porthetria dispar* (Linnaeus)) with terrain

and local growth. Williams (1939) reported that an elevated light trap (35 feet above the ground) collected not only a greater number of species and individuals, but also a larger percentage of females than a trap located at ground level. This effect was stronger in some species than in others. Saario et al. (1970) confirmed differences in capture of one species (*Trichoplusia ni* (Hübner)) with pheromone-baited traps at different heights from the ground.

The time of collecting also appears to be an important factor. Williams (1935, 1939), Hamilton and Steiner (1939), Hutchins (1940), and Graham et al. (1964) have demonstrated differences in activity peaks related to time of night. These studies also suggest that activity patterns may be a function of temperature, humidity, wind, cloud cover, etc. However, Saario et al. (1970) could not find correlations relating daily capture variations (one species at pheromone trap) with nightly variations in temperature, relative humidity, or full moonlight. But Shorey (1966) has noted a greater range in copulation timing under naturally fluctuating outdoor conditions, and points out that some of these variables (e.g. humidity) are difficult to assess in nature because of great variation within microenvironments. Edwards (1962) and Saario et al. (1970) have shown that the time of median capture relative to sunset may vary with moth age and the season.

The present study represents an attempt to compare collecting procedures used in sampling members of a single genus (*Catocala*). Direct comparisons of collecting procedures at a single location (but not always the same season) are made by means of rank correlations of species. Rank correlations of species collected at different localities, using both similar and different collecting procedures are also listed, although they may be less meaningful than those obtained simultaneously at one location.

Studies on *Catocala* are generally limited to the turn of the century (Bailey, 1877; Bunker, 1874; French, 1880; Johnson, 1880, 1882; Rowley, 1908, 1909; Rowley and Berry, 1909-1914), but recently some comparisons within the genus have been made when different sampling methods were involved (Sargent and Hessel, 1970). Hopefully the data in this report may aid in interpreting prior comparisons, as well as comparisons which might be made in the future.

#### METHODS

A total of approximately 11,750 records of individual adult *Catocala* were obtained from four localities in southern New England: (1) West Hatfield, Mass. (1622 records, 1969-70, CGK); (2) Pelham, Mass. (544



TABLE 1. Summary of collecting procedures and data.

Area	Year	Method <sup>a</sup>	Time Season	Time Night <sup>b</sup>	No. Indiv.	No. Species
West Hatfield	1970	RT (W)	7/13-8/26	Dusk-Dawn	273	24
		RT (F) <sup>c</sup>	8/23-9/26	Dusk-Dawn	692	26
		Bait	7/13-9/26	< 2400 hrs.	198	19
	1969	Bait	7/20-9/26	< 2400 hrs.	459	21
Leverett	1970	RT	7/28-10/16	> 2300 hrs.	1161	31
		UV	July-Oct.	< 2300 hrs.	169	23
		Spots	July-Oct.	< 2300 hrs.	91	23
		Bait	July-Sept.	< 2300 hrs.	85	8
	1969	UV	July-Aug.	< 2300 hrs.	41	18
		Spots	July-Aug.	< 2300 hrs.	36	10
		Bait	July-Aug.	< 2300 hrs.	188	13
	1968	Spots	July-Sept.	< 2300 hrs.	30	9
		Bait	July-Sept.	< 2300 hrs.	309	15
	1967	Spots & Bait	July-Sept.	< 2300 hrs.	311	21
Pelham	1966	Bait	July-Sept.	< 2300 hrs.	294	21
	1965	Bait	July-Sept.	< 2300 hrs.	195	20
	1964	Bait	July-Sept.	< 2300 hrs.	55	16
Washington	1970	RT	Entire <sup>d</sup>	Dusk-Dawn	886	30
	1969	RT	Entire	Dusk-Dawn	579	28
	1968	RT	Entire	Dusk-Dawn	424	29
	1967	RT	Entire	Dusk-Dawn	1151	35
	1965	RT	Entire	Dusk-Dawn	553	32
	1964	RT	Entire	Dusk-Dawn	530	30
	1963	RT	Entire	Dusk-Dawn	306	31
	1962	RT	Entire	Dusk-Dawn	1412	29
	1961	RT	Entire	Dusk-Dawn	1275	33

<sup>a</sup> RT—Robinson Trap; W—woods; F—field.<sup>b</sup> <—before; >—after. Times are approximate as given and constitute the majority of the records.<sup>c</sup> Woods and field sites totaled had 965 individuals of 31 different species.<sup>d</sup> Trap was operated both before and after seasons of *Catocala* flight.

records, 1964-66, TDS); (3) Leverett, Mass. (2471 records, 1967-70, TDS); (4) Washington, Conn. (7116 records, 1960-70, Sidney A. Hessel). Brief descriptions of these localities, and comments regarding collecting procedures in each, follow. A summary of collecting procedures and data is in Table 1.

#### (1) WEST HATFIELD, MASS.

**Description:** The West Hatfield (Hampshire County) site lies 2.2 miles west of the Connecticut River and 5 miles north of Northampton. Farm, woods, and swampland lie between the site and the Connecticut River. To the west are the foothills of the Berkshires. Collecting was done in mixed deciduous woodlands in an area locally referred to as "The Rocks." At the collecting site there is a 140 foot rise in elevation within 800 feet (U.S. Geological Survey Maps).

**Collecting procedures:** Collecting was done at bait (a brown sugar-cooking wine-

grape juice mixture painted on 20 trees along a trail at "The Rocks") in 1969 and 1970 on a daily basis from approximately 15 July to 20 September. Only nights of heavy rain, and about a half dozen single day absences, were missed for the two years. The mixture was usually applied fresh every night about a half hour before dusk, and trees were checked regularly every half hour until about midnight. On nights of much *Catocala* activity, the trail was checked more frequently and until 0200 hours, at which time there usually appeared to be a lapse in feeding by the moths. Occasional collecting after midnight rarely added any individual records on nights of poor *Catocala* activity. Daily records were kept on the species, sex, and time of activity.

In 1970 collecting was done at one Robinson mercury vapor light trap. The trap was turned on at dusk and left running until shortly after dawn at which time the contents were examined, and the species and sex of each individual *Catocala* recorded. The trap was operated every night, regardless of weather or absence. Attempts were made early in the season to check contents at intervals during the night, but the activity of the trapped moths made this unfeasible.

From 13 July to 22 August, the trap was located in the woods about 30 yards from the wood's edge atop a rock ledge. The trap could be seen for some distance within the woods, although view was restricted in some directions due to neighboring rock ledges. The trap was in view of nearly every tree on the sugar trail. From 22 August to 21 September the trap was located in a new situation about 250 yards to the northeast. Here the trap was in an open field about 50 yards from the edge of the main woods. A row of pine trees was immediately behind the trap. From 23–26 August a second Robinson Trap was borrowed and traps were run at both locations simultaneously.

## (2) LEVERETT, MASS.

**Description:** The Leverett (Franklin County) location is 4 miles east of the Connecticut River and 7.5 miles northeast of the collecting site at West Hatfield (USGS Maps). Collecting was done on a level area at the top of a hill. At the fringe of the Pelham Hills, this area consists primarily of mixed deciduous woodland similar to that at West Hatfield. There is also some vegetation typical of earlier seral stages of old field succession within the area.

**Collecting procedures:** *Catocala* were taken from 1967–70 at bait (brown sugar-beer mixture), at several 150-watt Westinghouse outdoor spotlights, and at rest. The data for sugar and lights were not separated in 1967. One 15 watt black light fluorescent tube was added in 1969 and 1970, and one Robinson mercury vapor light trap was added in 1970 (beginning 28 July). Collecting was done on a daily basis from 1 July to 1 September with only occasional 1–2 day absences. All collecting procedures (except bait) were continued until mid-October in 1970.

The Robinson Trap was located in a small open area only 10 yards from the edge of the woods. It was shaded through approximately 90 compass degrees by a house, but was visible from all trees on the sugar trail. Records for the trap were kept every night except for five days in late August when the trap was being used in West Hatfield. The trap was running only from 2300 hours to dawn until 10 September when it was left running from dusk to dawn for the remainder of the season (also running all night on 28–29 August when CGK kept the records for the Leverett location). The bait trail was checked and the other light sources were usually kept running until 2300 hours. Sex and time of activity data were kept beginning in 1968.

## (3) PELHAM, MASS.

**Description:** The Pelham (Hampshire County) site, which is 2.5 miles east of Amherst, is 4.2 miles south-southeast of the Leverett site, and 8.5 miles east of the West Hatfield site (USGS Maps). Collecting was done in an acre of woods in a

residential area. The soil is sandy and vegetation is that found in a pitch pine (*Pinus rigida* Mill.) community. Ornamental trees and shrubs, including various Rosaceae and honey locust (*Gleditsia triacanthos* L.) are common.

**Collecting procedures:** Collecting was done during the summers of 1964–66 and was limited to bait. Individuals were not routinely sexed, and times of capture were not noted.

#### (4) WASHINGTON, CONN.

**Description:** This collecting area (Litchfield County) has been described in Sargent and Hessel (1970). The mixed deciduous woodlands here have more Juglandaceae representatives, particularly butternut (*Juglans cinerea* L.), than localities in the Amherst area 65 miles to the Northeast.

**Collecting procedures:** Records of *Catocala* here were predominantly taken at one Robinson mercury vapor light trap with a few records taken at one 15 watt black light fluorescent tube. The lights were in operation all night from mid-March to mid-November of each year, with continuous records provided from 1961–70 (except 1966). Data on sex were not routinely kept.

The *Catocala* were identified as keyed and described in Forbes (1954) and foodplants were also taken from that source. Certain similar species (*C. gracilis* Edwards, *C. sordida* Grote; *C. crataegi* Saunders, *C. mira* Grote, *C. blandula* Hulst) were not always identified as to species. *C. gracilis* and *C. sordida* were distinguished by TDS and CGK in 1970 and *C. crataegi*, *C. blandula* and *C. mira* by CGK in 1969–70 (collected specimens only), TDS in 1970 and S. A. Hessel since 1961.

The rank correlation of species was found using the Spearman test (Siegel, 1956) with the correction factor for tied ranks being used in every case. The Spearman coefficient was also used to find the probability under a Student's *t* distribution that correlations between ranks were due to chance. In cases where certain species were not distinguished in one of the samples being compared, a single rank was given to the total number of individuals of these species in both samples.

## RESULTS AND DISCUSSION

### Comparison of Collecting Procedures

The rank correlations of species collected at a single location by different procedures, as well as by similar procedures in different years, are listed in Table 2. Whenever possible, correlations (of different procedures) are from comparisons of samples taken during the same season. The correlations are grouped according to location—West Hatfield, Leverett, and Washington—and are arranged within each group in decreasing order of similarity of species ranks.

The following observations derived from data in Table 2 seem most interesting. At both Leverett and West Hatfield, there were higher degrees of similarity between samples taken at bait in two consecutive

TABLE 2. Rank correlations of species across different procedures (or seasons) at a single locality.

Area	Procedures (or Seasons) Compared		N	$r_s$	$P_{r_s}$	t	$P_t$
	A	B					
W. Hatfield Bait	1969	1970	23	.653	< .01	3.92	< .0005
W. Hatfield 1970	RT	Bait	32	.469	< .01	2.91	< .005
Leverett 1969-70	Spots	UV	27	.841	< .01	7.77	< .0005
Leverett	UV, Spots 1968-70	RT 1970	29	.778	< .01	6.46	< .0005
Leverett Bait	1969	1970	14	.557	< .05	2.28	< .025
Leverett 1968-70	UV, Spots	Bait	28	.337	> .05	1.83	< .05
Leverett	RT 1970	Bait 1968-70	29	.238	> .05	1.29	> .10
Leverett 1970	Light (total)	Bait	30	.193	> .05	1.04	> .10
Washington RT	1965	1969	33	.831	< .01	8.31	< .0005
Washington RT	1963	1967	36	.712	< .01	5.91	< .0005

N—Number of different species for combined procedures.

 $r_s$ —Spearman Rank Correlation Coefficient. $P_{r_s}$ —Probability associated with Spearman Coefficient.

t—Student's t value.

 $P_t$ —Probability associated with Student's t value.

years than there were between bait and lights within a single year. The correlation was statistically significant for West Hatfield but only marginally so for Leverett. At Leverett the highest correlation occurred between samples taken at spot lights and a UV light summed over two years, with samples taken at UV and spots combined also showing a high correlation with the Robinson Trap. This is not surprising if the spectral composition of a light source is not important (Robinson and Robinson, 1950).

The higher degree of similarity between spots and UV, if significant, may be explained by the simultaneous operation of these light sources, while the Robinson Trap was sampling activity during a different time of the night. The higher degree of similarity between UV and spots combined and bait, than between the Robinson Trap and bait may be similarly explained.

TABLE 3. Rank correlations of species across different localities using similar and different collecting procedures.

Procedure	Area A	Area B	N	$r_s$	$P_{r_s}$	t	$P_t$
Lights 1970	WH	L	31	.843	< .01	8.32	< .0005
RT—1970	WH	L	31	.811	< .01	7.46	< .0005
Totals 1970	WH	L	33	.793	< .01	7.25	< .0005
Lights 7/13–8/22 1970	WH (woods)	L	25	.851	< .01	7.77	< .0005
Lights 8/27–9/21 1970	WH (field)	L	29	.669	< .01	4.68	< .0005
Bait 1968–70	WH	L	25	.495	< .01	2.73	< .01
Bait	P 1964–66	L 1968–70	26	.715	< .01	5.01	< .0005
Bait	WH 1969–70	P 1964–66	30	.262	> .05	1.44	< .10
RT 1970	WH 1970	W 1967	35	.549	< .01	3.80	< .0005
RT—1970	WH & L	W	35	.492	< .01	3.25	< .005
Lights 1970	L	W	34	.444	< .01	2.80	< .005
RT—1970	L	W	32	.435	< .01	2.65	< .01
Totals to 1969	WH & L	W	36	.349		2.17	< .025
1970	WH & L No RT	W	37	.231		1.40	< .10

Symbols same as in Table 2.

Localities are designated as follows: Leverett (L), Pelham (P), West Hatfield (WH) and Washington (W).

It is equally interesting that a very high degree of correlation occurred between two separated years of sampling by a Robinson Trap at a single location (Washington), even when there was nearly a fourfold difference in total moths taken (e.g. 1967 vs. 1963).

### Comparison of Localities

Table 3 lists rank correlations of *Catocala* species collected at different localities, using both similar and different collecting procedures. The interpretation of these correlations may be somewhat equivocal. When comparing across localities (and seasons), presence or absence of correlation might be due to either similarities or differences in 1) collecting procedures, or 2) the populations being sampled.

Samples taken at light sources at West Hatfield and Leverett during the same year appear to be statistically identical. This is not surprising since the vegetation is quite similar at the two locations. However this identity is barely maintained when comparing the populations taken at bait from the same two locations.

The populations sampled by light at Washington and both localities in the Amherst area during the same year have a high degree of similarity, although less than that between West Hatfield and Leverett. The decrease in similarity is not surprising, considering the greater abundance of Juglandaceae species as well as the singular presence of bayberry (*Myrica pensylvanica* Loisel.) at Washington. However, the similarity existing in populations is not as evident when different collecting procedures have been used over different years (combined data before 1970 which is presented by Sargent and Hessel, 1970, as well as 1970 analysis of combined Amherst areas without Robinson Trap vs. Washington).

Pelham and West Hatfield both seem to be better baiting areas than Leverett (number of species as well as number of individuals) although the high degree of similarity at bait occurs between Pelham and Leverett, with Pelham and West Hatfield having a correlation which is not even statistically significant. This can apparently be explained by a disparity between moths within the major foodplant groups which are active at bait in these localities—Salicaceae and Juglandaceae feeders predominating at West Hatfield, and Rosaceae and Ericaceae feeders predominating at Pelham, and to a great extent at Leverett as well. Since species within these foodplant groups are relatively similar in abundance at light in West Hatfield and Leverett, this further suggests that collecting at bait and light measures different kinds of activity.

It is impossible to determine which collecting procedures give a better representation of the population present in a locality without actually knowing what this population is, independent of the collecting procedures. Since all collecting procedures appear to miss species which appear to be reasonably common in a given locality (e.g., *C. cara* Guenée and *C. amatrix* (Hübner) at light and several Juglandaceae feeders at bait), a combination of collecting procedures would seem to be the best choice

when sampling *Catocala* populations. Generally speaking, light trap samples seem to be more consistent from year to year and yield larger samples (both in terms of species and individuals) than other procedures.

### Location of Robinson Trap

The location of the light trap appears to be an important consideration if the researcher is interested in assessing the number of moths in a given area. Data to support this contention were obtained when the trap operated in West Hatfield was moved from a woods to a field site in the middle of the 1970 season. The trap operated at Leverett was kept at the same location for the entire season and thus served as the control in this experiment. Since the effective range of the mercury vapor lamp trap is reputed to be about 100 yards (Robinson and Robinson, 1950), the normal movement of adult *Catocala* to be greater than 200 yards (Brower, 1930), and the vegetation of the woodlands to be roughly homogeneous across both West Hatfield trap sites, one can assume that the populations being sampled at the two West Hatfield trap sites were virtually identical.

From Table 3 it can be seen that samples from both West Hatfield sites shared a close correlation with the Leverett trap, a fact which was not surprising considering the wooded location of the control area. However, more surprising was the difference in numbers captured at the two locations. Because *Catocala* are active in the woods, one might intuitively expect that a trap located there would collect more moths than the same trap located in a field 50 yards from the wood's edge. However, Fig. 1, which graphically depicts the average number of species and individuals captured per day over five-day intervals during the 1970 season, reveals that the trap located in the field was much more effective than the same trap located in the woods.

Because the control trap was operating continuously and simultaneously with the experimental trap and showed no major seasonal differences in moth activity, it dramatically reinforces the conclusion that seasonal differences are not important factors in the increased effectiveness at the field site. The four-day interval when traps were operated at both wood and field sites lends further support. It is interesting that the field and control traps show nearly identical curves for activity of species and individuals. The greater effectiveness of the field trap over the control in the mid-portion of the season can be explained both by the greater abundance of a single species (*C. ilia* (Cramer)) at the West Hatfield location, and a difference in collecting procedures (field trap was operated all night whereas the control trap was operated only after 2300 hours). The near identity of activity in the field and control traps during the latter portion

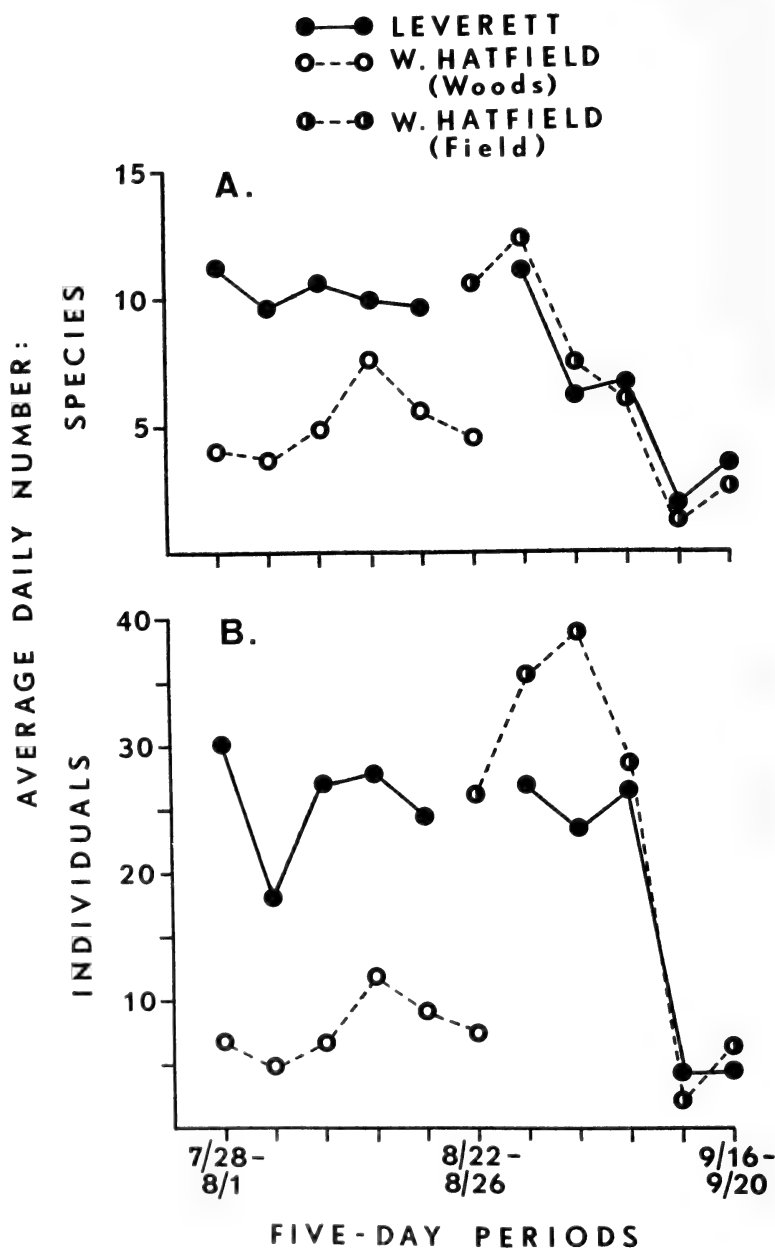


Fig. 1. Average daily capture of *Catocala* species (A) and individuals (B) in a Robinson Trap over successive 5-day periods at three locations in 1970.



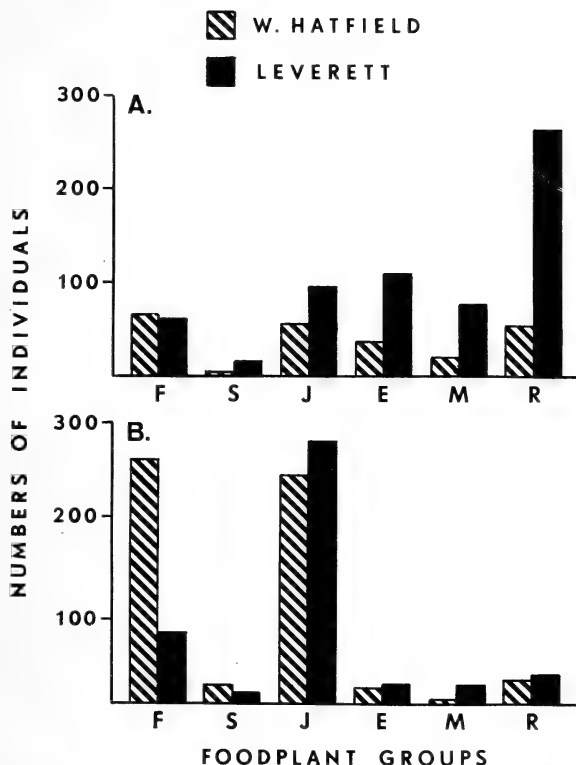


Fig. 2. Numbers of individuals of each *Catocala* foodplant group captured in Robinson Traps in West Hatfield (A, woods, 13 July–26 August; B, field, 22 August–21 September) and Leverett (A, 28 July–26 August; B, 22 August–21 September) in 1970. Foodplant groups are: Fagaceae (F), Salicaceae (S), Juglandaceae (J), Ericaceae (E), Myricaceae (M), and Rosaceae (R).

of the season also corresponds to the period when both traps were operated all night.

Examination of Fig. 2 points out that the increased effectiveness of the field over the woods site relative to the control is true for all foodplant groups with the exception of the Myricaceae. Also of the twenty species which were active both before and after the experimental trap was moved, 80% (i.e., all but four) had an increase in numbers relative to the control when the trap was relocated in the field.

One naturally wonders why the trap located in the field was more effective than the same one located in the woods. The answer may be found with reference to the work of Robinson and Robinson (1950). They concluded that a light source is not an attractant to moths; rather activity at light merely reflects activity of moths within the "inner dazzle sphere" of

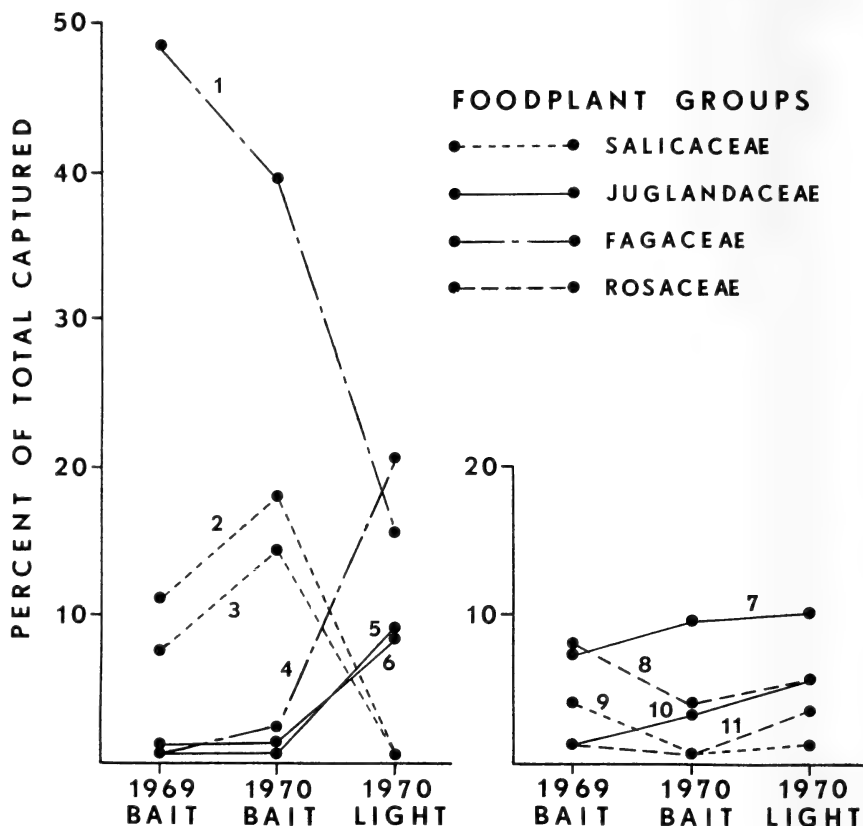


Fig. 3. Percentages of total individuals of some "common" *Catocala* species captured at bait and a Robinson Trap in West Hatfield in 1969 and 1970. Species fluctuating greatly with collecting procedures (to the left) include: 1) *ilia*, 2) *cara*, 3) *amatrix*, 4) *amica*, 5) *habilis*, and 6) *palaeogama*. Species relatively constant across collecting procedures (to the right) include: 7) *retecta*, 8) *ultronia*, 9) *concupens*, 10) *epione*, and 11) *grynea*.

the light source. If this is true, one would suspect that large trees and rock ledges around the trap would form shadow cones within the "dazzle sphere," enabling moths to escape. The shadow areas cast in this zone from the trap located in the field are much smaller and might very well account for the difference in effectiveness. The control trap was located near the wood's edge, and it might be expected that shadows interrupting the "dazzle sphere" of this trap were not as great as those cast by the trap in the woods, and might have been intermediate between those cast by the traps at the field and woods sites. Attractant theories may also provide an answer if one views shadow cones as breaking areas of attraction.

Williams (1939) has commented on the surprising success of a trap in an open and unsheltered location previously thought not to be a particularly good location for insects.

### Collecting Procedure Comparison by Species

An examination of the samples taken by various collecting procedures suggested that species feeding on certain foodplants were much more commonly collected by one procedure than another. Further, relative differences in activity at bait and light were not uniform for all species feeding on the same foodplant. These differences are graphically presented in Fig. 3. Data used in this figure are from the records of CGK from West Hatfield.

In general, it appears that very different collecting procedures, e.g., bait and light, are not sampling identically from the same population. Further, there appears to be consistency (in terms of species rank correlations) across seasons in samples taken by the same collecting procedures.

Fig. 3 illustrates the percentage of total *Catocala* collected for several common species within the genus. Generally, percentage differences between two years at bait are minimal for each species, whereas differences in the same year between bait and light are often dramatic. For example; *C. ilia* comprised about 50% of all *Catocala* collected at bait (and greater than 90% of all Fagaceae feeders at bait), but was dominated by another Fagaceae feeder, *C. amica* (Hübner), at light. Similarly *C. cara* comprised nearly 50% of all Salicaceae feeders at bait, yet was uncommonly collected at light. On the other hand, *C. concumbens* Walker, which was relatively uncommon at bait, was the most common Salicaceae feeder in the light trap. Common species within the same foodplant group (defined as all *Catocala* feeding on that foodplant), generally appear to parallel each other in activity at bait and lights (e.g., *C. cara* and *C. amatrix*; *C. paleogama* Guenée and *C. habilis* Grote). Three Ericaceae feeders, *C. gracilis*, *C. sordida* and *C. andromedae* (Guenée), were commonly taken at lights, but only one individual of the three species was taken at sugar for the two years. These results can be essentially replicated with data collected by TDS in Leverett.

### SUMMARY

*Catocala* populations taken by various collecting procedures at four localities in southern New England were compared using species rank correlation coefficients. Highest correlations were obtained when the same procedure was used and when collecting was done during the same time of night. These correlations were greater for light sources than for

baits. A comparison of samples taken in a light trap located at a field and woods site showed a similar degree of correlation to a control, but there was much greater effectiveness of the trap at the field site.

#### ACKNOWLEDGMENTS

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The many records generously provided by Sidney A. Hessel from several years collecting at one site using the same collecting procedure are gratefully acknowledged.

Sincere thanks are also given to Yale University for loan of one of their Robinson Traps, and to L. Vollinger and K. Fisher for use of their land for collecting.

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### THREE BUTTERFLY SPECIES (LYCAENIDAE, NYMPHALIDAE, AND HELICONIIDAE) NEW TO TEXAS AND THE UNITED STATES<sup>1</sup>

ROY O. KENDALL<sup>2</sup>

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The author (1970) gave five species of *Rhopalocera* new to Texas and the United States which were probably introduced through Hurricane Beulah of 1967. Three more species are now added. Time and additional research would be required to determine the specific ecological factors influencing permanent residence should any of these become established north of the Rio Grande.

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<sup>1</sup> Contribution No. 206. Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville.

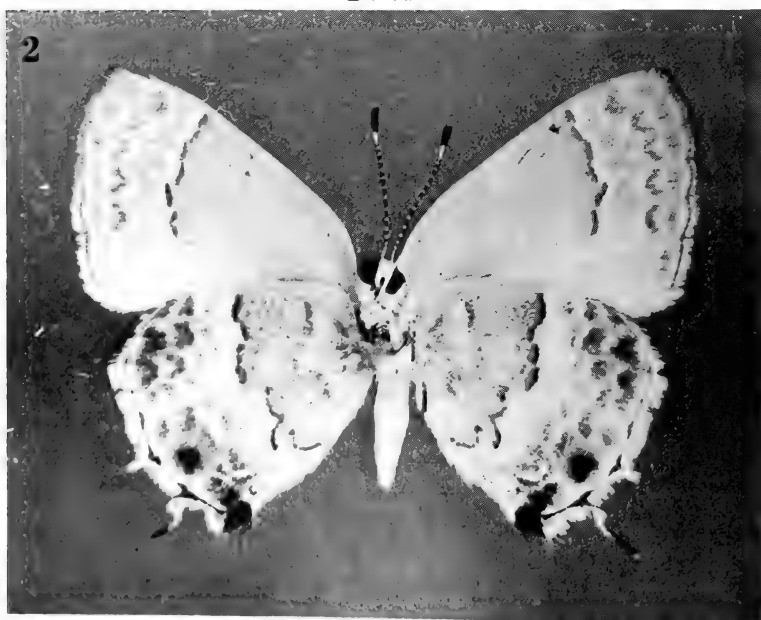
<sup>2</sup> Research Associate, Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

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Figs. 1-2. *Strymon alba sculecia* (Hewitson). Dorsal and ventral surfaces of male.

*Strymon albata sedecia* (Hewitson)

*Thecla sedecia* Hewitson 1874, Ent. Mo. Mag. 11: 105 (TL: "Mexico"); *ibid.* 1877, Ill. Diurn. Lep. Lycaenidae: 198, pl. 18 figs. 637, 638; Godman & Salvin 1887, Biol. C.-Amer., Rhop. 2: 94; Draudt 1920, in Seitz, Gross-schmett. Erde 5: 808, pl. 159 k; Hoffmann 1941, An. Inst. Biol. Mexico 11: 719 (#744); Comstock & Huntington 1963, J. New York Ent. Soc. 71: 116.

*Strymon albata sedecia*: Clench 1967, J. Lepid. Soc. 21: 183 (TL: restricted to Mazatlán, Sinaloa, Mexico).

This subspecies, formerly known only from Mexico and Guatemala, is now represented by four examples from Texas. Three of these, in fair to poor condition, were taken by Michael A. Rickard at the Santa Ana National Wildlife Refuge, Hidalgo Co.: 9 November 1968 (1), 24 November 1968 (1), and 14 December 1968 (1). The latter male is in the author's collection. The fourth example, a fresh male (Figs. 1 & 2), was taken by John E. Hafernik, two miles east of Brownsville, Cameron Co., 10 July 1970.

Based on these data, this species seems to be established in Texas at least temporarily. It may have been introduced by Hurricane Beulah of 1967. Once we have reared it and know more about its life history a more precise evaluation can be made of its residence status.

*Chlosyne rosita browni* Bauer

*Chlosyne rosita* Hall, 1924. Entomologist 57: 241-243, 2 figs. TL: Western Guatemala.

*Chlosyne rosita browni* Bauer, 1960. J. Lepid. Soc. 14 (2): 148-154, 2 figs. TL: El Salto, San Luis Potasi, Mexico.

This subspecies was described from 36 specimens from Mexico (San Luis Potosi, Nuevo Leon, and Tamaulipas). It is now represented in the United States by a good series (42♂, 9♀) of field-caught specimens plus nine (5♂, 4♀) reared examples, all from Santa Ana National Wildlife Refuge, Hidalgo Co., Texas. Bauer (1960), in describing this subspecies, suggested that it might be found in the United States.

On 24 October 1970, the author and Mrs. Kendall joined our very good friend Dr. J. W. Tilden at the Santa Ana National Wildlife Refuge for a weekend of collecting. On this day while collecting near the Dicliptera Trail, the author saw an adult but missed catching it. A few minutes later Mrs. Kendall took a fairly good male (possibly the same specimen). On the following morning, the insect was common along the Dicliptera Trail. Fourteen examples (13♂, 1♀) were collected. On 26 October, same location, we took seventeen more (13♂ 4♀).

Adults collected were mostly worn and were found mainly at two spots along the trail where *Dicliptera brachiata* (Pursh) Spreng var. *alternata* Gray and *Dicliptera vahliana* Ness (*Acanthaceae*) grow. At one spot both

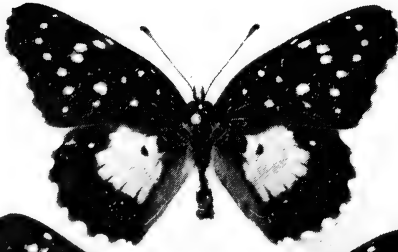
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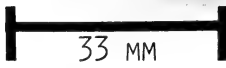
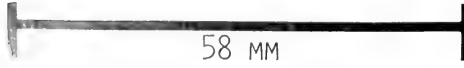
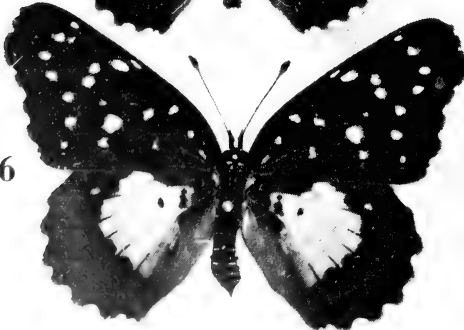
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plant species were growing together. The first named is a perennial, the latter an annual. At the last spot, in particular, males were observed flying back and forth low over these plants, apparently searching for virgin females. The females taken were sitting on these plants, leisurely flexing their wings in a preoviposition manner.

All four females taken 26 October were kept alive for egg production in the laboratory. Female Nos. 1, 2 and 3 each deposited a single multi-cluster of eggs beneath a leaf of *D. alternata* 27 October; females 1 and 2 were then placed in a killing jar. Female No. 3 deposited another cluster on 29 October and two more small clusters 31 October. No. 4 female deposited clusters 28 and 30 October. Both remaining females were placed in the killing jar 31 October. All egg clusters were deposited beneath leaves in a typical *Chlosyne/Phyciodes* manner.

Eggs started hatching about 0600 on 5 November. Most first instar larvae were lost, reason undetermined, but the absence of fresh foliage suspected. A few remaining larvae were offered fresh foliage of *Siphonoglossa pilosella* Torr., which they readily ate. Later instars accepted *D. alternata*, the most likely preferred oviposition substrate. Pupation occurred: 6-XII (3), 7-XII (1), 8-XII (3), and 10-XII (3). Adults emerged: 13-XII (2♂, 1♀), 14-XII (1♂), 15-XII (2♂), 17-XII (2♀), and 18-XII (1♀) for a total of 5♂, 4♀. Preserved immatures include one small cluster of eggs, all first instar larvae that died, one last instar larva, and one pupa. Also, one small cluster of eggs was furnished Dr. Alvah Peterson for color photographing.

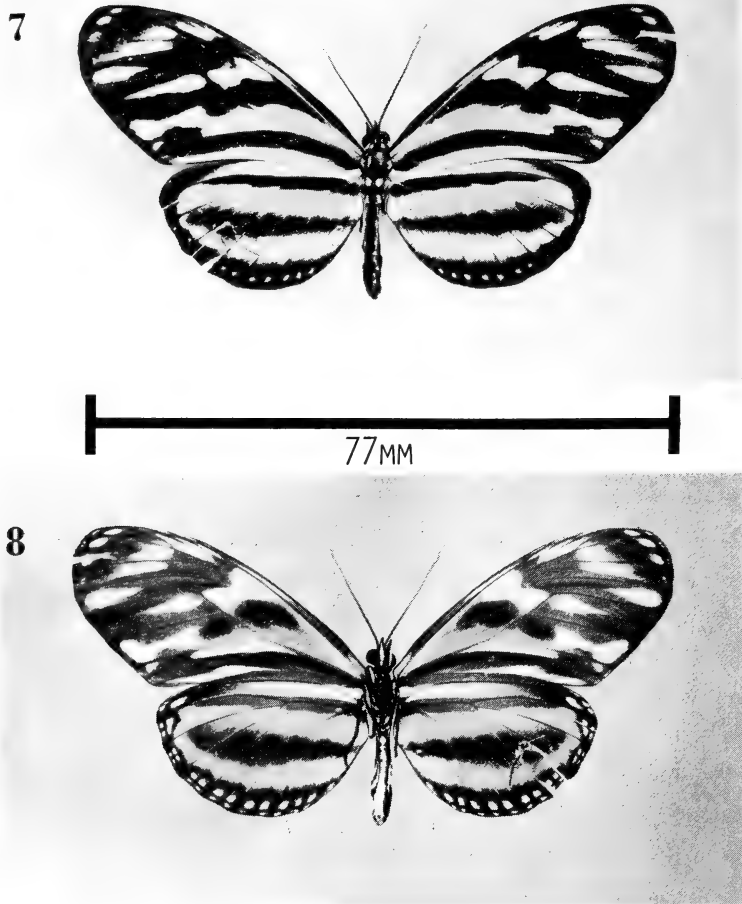
Following our lead, Tilden collected the same area during the period 25 October–17 November and took twenty (16♂, 4♀) examples. Those taken near the end of the period were badly worn, and several additional examples were released after capture. At the time we collected these specimens, we were under the impression they represented *Chlosyne janais* Drury. After returning to the laboratory and reexamining the specimens, the author realized this insect was not *C. janais*. Tilden kindly paid us a departing visit on 18 November at which time we discussed the matter. Upon returning to California, Tilden soon discovered by checking the literature and specimens in the California Academy of Sciences Museum that our insect was *C. r. browni*. He also discovered among his catch three examples (2♂, 1♀) of *C. janais* which had been taken in

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Figs. 3–4. *Chlosyne rosita browni* Bauer. Dorsal and ventral surfaces of male and female.

Figs. 5–6. *Chlosyne janais* Drury. Dorsal and ventral surfaces of male and female.



Figs. 7-8. *Eucides cleobaea zorcaon* (Reakirt). Dorsal and ventral surfaces of female.

another part of the Refuge. On the chance this confusion may have happened to other collectors, the two species are illustrated (Figs. 3-6). The similarity is sufficiently great as to suggest a mimic/model relationship. Superficially, the larvae are more easily separated than the adults, although there should be no confusion when the adults of each are compared.

Based on available collection records, it would appear this subspecies has perhaps four broods. It probably has an inherent larval diapause,

manifested in a few immatures only, which may be triggered by temperature. Additional field research is necessary to determine this. Further, it is unknown whether the species is a permanent resident in Texas.

*Eueides cleobaea zorcaon* (Reakirt)

- Eueides* Hübner, 1816. Verz. bekannt. Schmett. (1): II; type species *Nereis dianassa* Hübner [1806]. Samml. exot. Schmett. 1: pl. [8], selected by Scudder, 1875, Proc. Acad. Arts Sci., Boston 10: 169.
- Eueides zorcaon* Reakirt, 1866. Proc. Acad. Sci. Phila. V. [18], 243, no. 12. (TL: Near Vera Cruz, Mexico); Fassl, A. H., 1909, Jugendzustände Trepischer Tagfalter. Soc. Ent. 24: 105-107 (mentions larval foodplant, egg and larva); Seitz, A., (1913), Vol. 5, p. 398 [pl. 80g], (ranging through Central America as far west as Mexico); Wolcott, G. H., 1923, Insectae Portoricensis, J. Dept. Agr. Puerto Rico 7 (1): 1-313 (records *Passiflora* sp. as larval foodplant); Seitz, A., 1924, Die Gross-Schmetterlinge der Erde. Vol. V. Die Amerikanischen Tagfalter. Stuttgart, 1141 pp. (describes egg, generic larva, and records *Passiflora* sp. as larval foodplant). Wolcott, 1936, Insectae Portoricensis, J. Dept. Agr. Puerto Rico 20: 1-627 (again records *Passiflora* as larval foodplant).
- Eueides cleobaea zorcaon*: Neustetter, H., 1929, Lepidopterorum Catalogus (makes *zorcaon* a subspecies of *cleobaea* Geyer); Hoffmann, C., 1940, Catalogo Sistemático y Zoogeográfico de los Lepidopteros Mexicanos. An. Inst. Biol. Mex. 11 (2): 639-739 (gives range as warm and hot regions of the Gulf Coast and Chiapas); Ross, Gary N., 1964, Life history studies on Mexican butterflies, J. Res. Lepid. 3 (4): 207-229 (describes the egg, larva [1-5 instars], and pupa; illustrates, in black and white, adult [upper side], egg, 5th instar larva, head capsules of 1st and 5th instar larvae, and pupa [dorsal and lateral views]).

This subspecies, previously known only from Central America and Mexico, is now represented in the Nearctic fauna by 13 examples, all from Texas. One of these is illustrated (Figs. 7-8). It would appear from collection dates that *zorcaon* has perhaps three broods when, from time to time, it becomes temporarily established north of the Rio Grande.

In 1966 the author examined three examples of this subspecies in the Panther Junction Museum, Big Bend National Park, Brewster Co., Texas. They were collected in the park by Rollin H. Baker, 15 July 1937 (1) and 22 July 1937 (2).

In 1968, thirty years later, this insect was distributed over a wide area in Texas, but it has not been seen since. Its reintroduction and temporary residence probably resulted from Hurricane Beulah of 1967. Known examples collected in Texas during 1968 are: Near Skidmore, Bee Co., 20 April (3), leg M. A. Rickard; same location and date, (2), leg Roy Jameson; two other specimens were sighted at this location. On the same day Rickard saw one example at Lake Corpus Christi State Park, San Patricio Co. San Antonio, Bexar Co., 21 April (1 ♀), leg Glenn Y. Belyea. Big Bend National Park, Brewster Co., 11 June (1), leg David A. Easterla; this specimen was feeding on blossoms of *Acacia greggi* Gray growing in the Chisos Mountains basin. McAllen, Hidalgo Co., 4 May (2 ♀), leg Dr.

J. Bolling Sullivan III. Santa Ana National Wildlife Refuge, Hidalgo Co., 24 June (sight record), 25 June (2♀), leg J. R. Heitzman.

#### ACKNOWLEDGMENTS

I wish to thank William T. Krummes, regional director, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Albuquerque, New Mexico, for providing the necessary permits to conduct basic research on the Lepidoptera in the Santa Ana National Wildlife Refuge. I also wish to thank Carrell Ryan and Wayne a Shifflett of the Santa Ana Refuge for their excellent cooperation in the conduct of this research.

I am also indebted to Harry K. Clench, Cyril F. dos Passos, William D. Field, Paddy McHenry, Dr. J. W. Tilden, and Dr. Howard V. Weems, Jr., for providing certain references and for reviewing the MS in whole or in part. Special thanks go to my good friend and fellow lepidopterist André Blanchard for taking time from his own research on Texas Lepidoptera (Heterocera) to photograph the species here recorded and illustrated.

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### MORE NEW MOTHS FROM TEXAS (NOCTUIDAE)

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This is a follow-up of the Blanchard 1966, 1968 and 1970 papers.

#### *Oncocnemis cottami*, A. Blanchard, new species.

Head: Black; scales on upper half of front, vertex, and base of antennae long, raised and whitish tipped; antennae simple; palpi rough scaled, whitish basally, blackish distally; second segment longest, not quite reaching middle of front; third segment very short, porrect.

Collar: Black basally, dark gray on top; the white band in between is itself divided in two by a thin black line.

Thorax: Disc and patagiae brownish gray; sordid white below; foretibia short, armed with a strong claw; each segment of foretarsus contrastingly dark basally, whitish distally; middle and hind tibiae loosely clothed with brown and whitish scales and long hairs.

**Abdomen:** Brownish gray on top, lighter beneath. The male has a pair of hair pencils in two grooves, one on each side at base of abdomen.

**Pattern of maculation:** Background of forewing a mixture of white and brown scales appearing as a powdery, light brownish gray; lighter basally near costa; darker basally between Cu and inner margin; transverse lines obsolete; a fusiform, slightly diffuse, black fascia runs along Cu from base to middle of wing; a thicker, fusiform, black fascia runs in the cell and beyond, almost from base to outer margin between M2 and M3; the space between these two fasciae is so dark as to give the appearance of only one big fascia, very thin at its ends, but covering about a fourth of the width of the wing in its middle; vein ends slightly darkened; darker, longer, intervenular dashes; a thin, black subcontinuous terminal line; fringe yellowish at extreme base, checkered distally, dark brown between vein ends; some specimens show the black outline of the claviform, immediately under the black fascia; orbicular and reniform obsolete. Hindwing of male iridescent white, blackish at vein ends and along a thin terminal line; fringe basally yellowish, white distally, with a thin brownish dividing line. Hindwing of female similar except for soiled veins and presence of a diffuse soiled band along outer margin. Undersurface of forewing white, brownish along costa, near apex, and along Cu; fringe as above. Undersurface of hindwing white, slightly soiled along costa; fringe white.

**Length of forewing:** 13 to 14 millimeters.

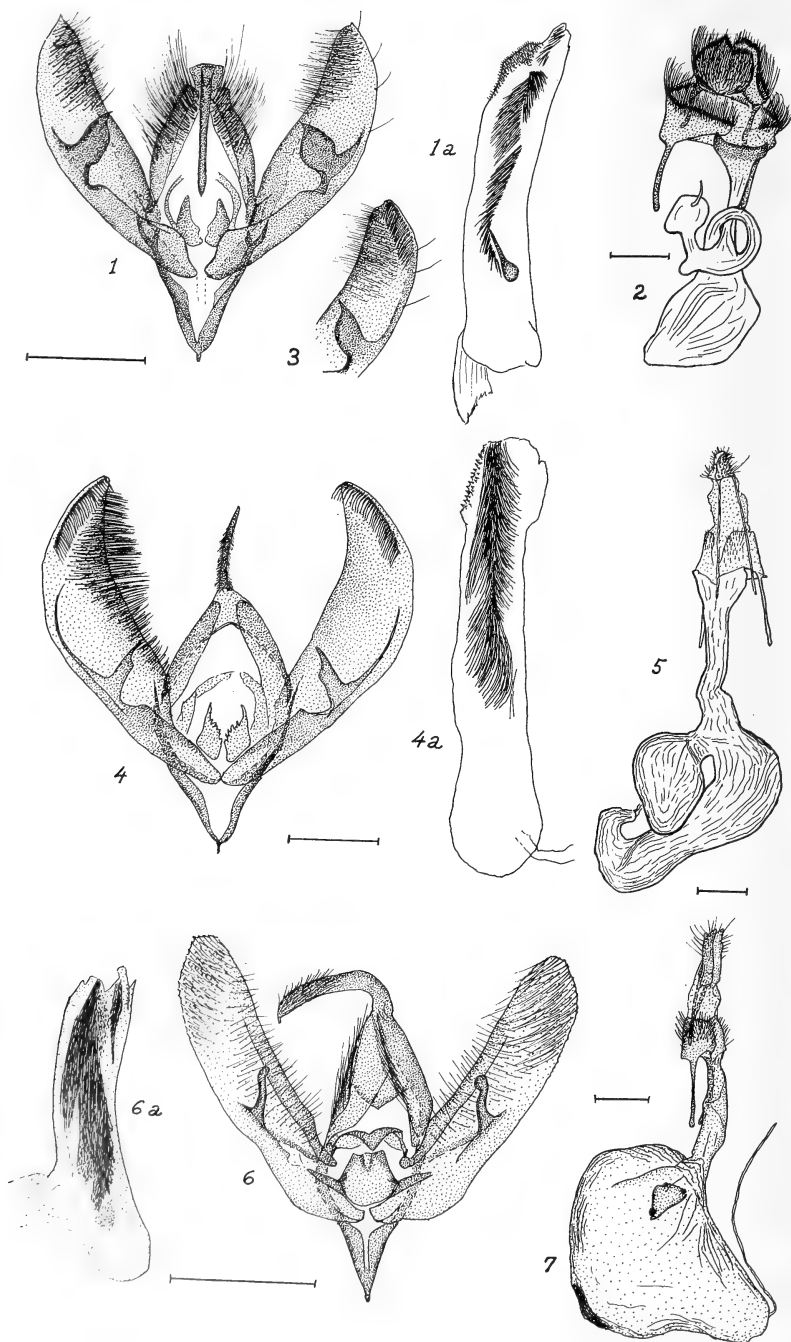
**Male genitalia:** As in Fig. 1 and 1a.

**Female genitalia:** As in Fig. 2.

**Holotype:** Male, Texas, Big Bend National Park, Basin, altitude 5500 feet, 10 May 1966, genitalia on slide A.B. 1050, deposited in the National Museum of Natural History, (No. 68147).

**Paratypes:** All taken in or around the Chisos Mountains of Big Bend National Park: Basin, 7 July 1964, 1 ♂; 10 July 1964, 1 ♂; 4 Aug. 1964, 1 ♂; 29 Aug. 1965, 1 ♂; 29 June 1965, 1 ♂, 1 ♀. Oak Spring, 9 July 1964, 3 ♂♂, 2 ♀♀; 5 Aug. 1964, 1 ♀; 31 Aug. 1964, 1 ♂. Green Gulch, 27 June 1965, 1 ♂; 25 Mar. 1971, 1 ♂; 28 Mar. 1971, 2 ♀♀. Government Spring, 27 Mar. 1971, 1 ♂. Paratypes will be deposited in the National Museum of Natural History, in the American Museum of Natural History, in the British Museum (Natural History) and in Dr. J. G. Frandemont's collection.

*Oncocnemis cottami* is very close to *O. atricollaris* Harvey. The transverse lines of *atricollaris* are generally well marked, sometime only partly traceable, rarely completely obsolete; the part of the reniform which falls below the upper black fascia generally shows as a pure white small pupil; the white median band of the collar appears narrower because its top half is much soiled with brown scales. If all three of these characters appear doubtful, one has to rely on the genitalia to remove all doubt. The valves of the male genitalia of *atricollaris* are broader, rounder, and present a well developed corona (Fig. 3); those of *cottami* have no trace of a corona. The female genitalia are also different, the ductus bursae of *atricollaris* goes directly into the bursa copulatrix, whereas it is much contorted in *cottami*. Distribution: *O. cottami* is known only from the Chisos Mountains of Texas. *O. atricollaris*, which is known from a large territory including parts of Colorado and Arizona and most of Texas, is either absent or quite rare in the Chisos Mts. *O. nigrocaput* Smith, another species of the same group, described from Colorado, also extends to Texas



it must also be quite rare as we have only two males, both taken 27 March 1971 at Government Spring in Big Bend National Park.

I take great pleasure in dedicating this new species to Dr. Clarence Cottam, Director of the Rob and Bessie Welder Wildlife Foundation. This is a privately endowed, non-profit organization, supporting educational and research activities, situated near Sinton in the San Patricio County of Texas. Dr. Cottam always made us feel welcome there.

### ***Oncocnemis heterogena*, A. Blanchard, new species.**

**Head:** Front covered with short, raised, black, white tipped scales; vertex with rough squamation of longer, black, ochreous tipped scales; tongue strong; palpi ascending, exceeding front by half eye diameter, first and second segments clad with rough scales, mixed on underside with much longer hairlike scales; first segment ochreous below, blackish laterally; second segment with more black than ochreous scales; third segment, the shortest, blackish. Antennae simple, dark reddish brown.

**Collar:** Wide, smooth, pinkish ochreous, more or less darkened by blackish scales.

**Thorax:** Disc and patagiae smooth, brownish black; whitish below. Legs blackish; segments of metatarsi distally ringed with pinkish ochreous; foretibia armed with claw.

**Abdomen:** Ochreous above, whitish below. The male has a pair of hair pencils in two grooves, one on each side at base of abdomen. The female presents a tuft of very dark reddish brown scales, below, at the tip of the abdomen.

**Pattern of maculation:** Maculation of forewing on upperside produced by mixture in variable proportions of scales of essentially two colors only: black and same pinkish ochreous as collar; these two colors about evenly mixed in background; three deep-black spots on costa: one adnate to and distad of t.a. line, one adnate to and basad of t.p. line, and one marking anterior origin of rather indistinct median shade; basal line pinkish ochreous, internally bordered by fine black line, extending from costa to cubital vein; t.a. line pinkish ochreous, outcurved between veins, generally slanted a little outwardly, with faint, discontinuous indication of black borders more definite near inner margin; t.p. line pinkish ochreous, narrow, outwardly convex and well beyond reniform between costa and M3, broader, lighter in color and outwardly concave between M3 and inner margin; s.t. line pinkish ochreous, very irregular and discontinuous; terminal line thin, black, varying from almost continuous to nearly obsolete; fringe grayish ochreous, checkered with darker gray between vein ends on better marked specimens; orbicular elongated, with dark center, outlined in pinkish ochreous; reniform with dark center, inwardly bordered with pinkish ochreous; these discal spots quite variable in intensity and sometimes obsolete; on some specimens the light color of the broader posterior part of the t.p. line extends into the subterminal space, contrasting with the always darker posterior part of the wing between transverse

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Figs. 1-7. Male and female genitalia. Scales shown equal 1 mm. Figs 1-2. *Oncocnemis cottami*: 1 and 1a, ♂ type, Big Bend National Park, Basin, slide A.B. 1050; 1, aedeagus omitted, 1a, aedeagus. 2, ♀, Big Bend National Park, Oak Spring, slide A.B. 2384. Fig. 3. *Oncocnemis atricollaris* Harvey, Lake Brownwood State Park, part of right valve, slide A.B. 1055. Figs. 4-5. *Oncocnemis heterogena*: 4 and 4a, ♂ type, Big Bend National Park, Green Gulch, slide A.B. 1059; 4, aedeagus omitted, 4a, aedeagus. 5, ♀, Big Bend National Park, Basin, slide A.B. 1354. Figs. 6-7. *Paramiana callaisata*: 6 and 6a, ♂ type, Guadalupe Mountains National Park, Pine Spring Canyon, slide A.B. 1138; 6, aedeagus omitted, 6a, aedeagus. Fig. 7, ♀, Guadalupe Mountains, Pine Spring Canyon, slide 1377.



8



9



10



lines. Hindwing white, darkened on veins and along diffuse narrow marginal band, somewhat wider and darker in the female than in the male; fringe yellowish basally, white distally, with narrow brownish median line. Undersurface of forewing smoky, darker along costa, varying to sordid white along inner margin; fringe varying from smoky to whitish and checkered. Undersurface of hindwing white, darker on veins, near apex and along narrow terminal line; fringe white.

**Length of forewing:** Male 15 to 16 millimeters; female 15 to 17 millimeters.

**Male genitalia:** As in Fig. 4 and 4a.

**Female genitalia:** As in Fig. 5.

**Holotype:** Male, Big Bend National Park, Green Gulch, 27 August 1965; genitalia on slide A.B. 1059, deposited in the National Museum of Natural History (No. 68148).

**Paratypes:** Big Bend National Park, Basin, 4 August 1964, 1 ♀; 4 Sept. 1964, 1 ♀; 29 Mar. 1965, 1 ♀; 25 Aug. 1965, 5 ♂♂, 2 ♀♀; 28 Aug. 1965, 1 ♂; 14 May 1966, 1 ♂; 7 April 1967, 1 ♂, 1 ♀. Big Bend National Park, Pine Canyon, 1 April 1965, 1 ♂; 8 April 1967, 1 ♂. Big Bend National Park, Green Gulch, 3 April 1965, 1 ♂, 3 ♀♀; 27 Aug. 1965, 1 ♂; 5 April 1967, 1 ♀; 25 Mar. 1971, 1 ♀. Sierra Diablo Wildlife Management Area, 22 & 23 June 1965, 3 ♂♂, 1 ♀; 20 May 1968, 11 ♂♂, 8 ♀♀; 5 to 7 June 1969, 6 ♂♂, 2 ♀♀; 14 & 15 July 1969, 7 ♂♂, 5 ♀♀; 1 Sept. 1969, 2 ♀♀; 31 Mar. 1970, 2 ♂♂, 1 ♀; 31 Aug. and 1 Sept. 1970, 4 ♂♂, 1 ♀.

It is remarkable, but probably not meaningful, that although the Davis Mountains lie between the Chisos Mountains of the Big Bend and the Sierra Diablo, this list does not include a single specimen from the Davis Mountains. It may more likely mean that our collecting spots, limited as they are to the few locations accessible by car, where our traps appear reasonably safe during the night, do not satisfactorily represent the Davis Mountains.

Paratypes will be deposited in the National Museum of Natural History, in the American Museum of Natural History, in the British Museum (Natural History) and in Dr. J. G. Franclemont's collection.

This species is quite variable, the transverse lines vary from well defined and contrasty, as they are in the holotype, to fuzzy and nearly obsolete; *Oncocnemis heterogena* appears to resemble *O. homogena* Grote most closely in the pattern of maculation and size, but it may be easily separated because the basal part of the forewing is not noticeably paler than the median area, and the t.a. line is differently colored than in *homogena*. In the latter species the t.a. line is uniformly dark brown and black, strongly contrasting with the remainder of the wing. In *heterogena* the t.a. line is composed of a thinner, less intensely colored line of brown scales bordered basally by a line as wide or wider of ochreous scales.

### ***Paramiana callaisata*, A. Blanchard, new species.**

**Head:** Retracted; front bulging, dusky, smoothly scaled; vertex roughly clad with white tipped, black scales; eyes large, slightly elliptical; palpi short, concolorous with front, ascending, barely exceeding front; first and second segments rough scaled, third segment smooth, shorter than second; antennae finely, shortly pubescent in male, simple in female.

←

Figs. 8–10. Male holotypes: 8, *Oncocnemis cottami*; 9, *Oncocnemis heterogena*; 10, *Paramiana callaisata*.

**Collar:** Disc of thorax and patagia covered with raised, white tipped, black scales, forming a high tuft on metathorax. Legs dusky, with loose, long hairs.

**Abdomen:** Fuscous above and below, with weak tuft on first segment.

**Pattern of maculation:** Maculation of forewing consisting mostly of hard-to-trace, transverse bands and fuzzy patches of black and green; basal band, when not completely obsolete, reduced to its inner black line, reaching from costa to anal vein; t.a. band substantially reduced to its fine, black, discontinuous outer border, starting on costa about one fourth distance from base to apex, slightly bulging between veins from costa to anal vein, squarely outcurved on anal vein and reaching inner margin almost at its middle; t.p. band poorly defined, median line paler than background, inner black line consisting of intervenular, finely confluent, black spots, outer line almost obsolete, in course arising on costa above reniform, outwardly bent just below costa to well beyond reniform, then parallel to outer margin, except for broad, shallow concavity in fold; s.t. line consisting of a succession of elongated, intervenular, black spots sprinkled in their center with green scales; terminal line reduced to intervenular, small, triangular, black spots; a white spot at vein ends; fringe concolorous with background, checkered, with a darker median line; orbicular small, green, outlined in black; reniform large, squarish, mottled yellowish green and black, broadly changing to bluish white at outer corners and along lower side; a black spot along inner margin midway between base and a.m. band; rest of area between basal and a.m. band well sprinkled with green scales; a.m. outer and p.m. inner lines enlarged in fold, forming there two black patches more or less connected by darker background; a large black patch basad of reniform; a green patch distad of p.m. band in fold; four to five white dots on costa, about equally spaced in its outer half. Hindwing of male light brassy ochreous, heavily sprinkled with brown scales forming two extramedial bands; terminal line brown, accented between veins; fringe concolorous with background, with medial brown dividing line. Hindwing of female more heavily sprinkled with brown scales. Undersurface of forewing dusky; with darker p.m. line; a terminal brown line; fringe concolorous, checkered. Undersurface of hindwing dusky, darker along costa, an extramedial line in continuation of that of the forewing.

**Length of forewing:** 18 to 19 millimeters.

**Male genitalia:** As in Figs. 6 and 6a.

**Female genitalia:** As in Fig. 7.

**Holotype:** Male, Guadalupe Mountains, Pine Spring Canyon, altitude 5700 feet, 28 August 1967; genitalia on slide A.B. 1138, deposited in the National Museum of Natural History (No. 68149).

**Paratypes:** Guadalupe Mts., Pine Spring Canyon, 28 Aug. 1967, 1 ♂, 6 ♀. Davis Mountains, Mt. Locke (McDonald Observatory), altitude 6000 feet, 25 Aug. 1967, 3 ♂♂; 30 Aug. 1969, 1 ♂; 6 Sept. 1969, 10 ♂♂, 12 ♀♀; 27 Aug. 1970, 2 ♂♂, 3 ♀♀; 29 Aug. 1970, 3 ♂♂, 2 ♀♀. Paratypes will be deposited in the National Museum of Natural History, in the American Museum of Natural History, in the British Museum (Natural History) and in Dr. J. G. Franclemont's collection.

The forty four specimens before me show very little variation. Separating *Paramiana callaisata* from other species in the same genus is a very simple matter since its maculation resembles that of no other previously described species that I have been able to compare it with in the National Museum. The distinctive whitish contrasting reniform spot separates it from all the other species of the genus. *Paramiana laetabilis* Smith also has a contrasting, large reniform spot, but it is blue in fresh unfaded specimens. The broad blue subterminal band of *laetabilis* is absent in the new species.

## ACKNOWLEDGMENTS

I wish to thank Dr. E. L. Todd of the Agricultural Research Service of the U.S. Department of Agriculture for revising the manuscript and for many useful suggestions. I also wish to extend my appreciation to the personnel of the Big Bend National Park, the Guadalupe Mountains National Park, the State-owned Wildlife Management Areas of Texas and the McDonald Observatory for authorizing us to collect at these places.

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- 

## A POSSIBLE CASE OF MIMICRY BETWEEN LYCAENID BUTTERFLIES (LYCAENIDAE)

Mimicry is a relatively common phenomenon among lepidopteran insects. Familiar North American examples have been studied extensively (e. g. Brower 1958, *Evolution* 12: 32-47, 123-136, 273-285). Recently, Downey (1965, *J. Lepid. Soc.* 19: 165-170) suggested a mimicry complex with several blues (Plebejinae, especially *Plebejus icarioides* Boisduval) serving as models for the noctuid moth *Caenurgina caerulea* Grote. Another possible case of mimicry with blues as models involves the male Blue Copper (*Lycaena heteronea* Boisduval). The striking superficial resemblance of the dorsal wing surface of the latter and blues has been noted often (Ehrlich and Ehrlich 1961, *How to Know the Butterflies*; Comstock 1927, *Butterflies of California*; Brown et al. 1957, *Colorado Butterflies*). The difference in coloration of the male *L. heteronea* from that of other coppers immediately suggests mimicry.

I suggest that the male of *L. heteronea* is a mimic of *Glaucopsyche lygdamus* Doubleday and possibly other sympatric blues. The dorsal coloration of *L. heteronea* is nearly identical to that of *G. lygdamus*. The geographical range and flight period of the copper appear to be entirely within those of the blue.

Furthermore, Batesian mimicry is indicated by at least three sets of data. The dorsal resemblance is nearly perfect. Batesian mimics tend to be more perfect than Müllerian (Ford 1964, *Ecological Genetics*). The food plant of the copper is *Eriogonum*; those of *G. lygdamus* include *Lupinus* and *Astragalus* among other legumes (Ehrlich and Ehrlich, op. cit.). *Lupinus* contains alkaloids (Robinson 1968, *The Biochemistry of Alkaloids*) and many *Astragalus* contain selenium; both are known to be poisonous to vertebrates (Kingsbury 1964, *Poisonous Plants of the United States and Canada*). If these compounds are incorporated into insect tissues, such insects may be poisonous or unpalatable to their predators. The mimic appears to be less common than its model (Comstock, op. cit.; Brown et al., op. cit.). In June and July, 1963, in Garfield County, Colorado (Coffee Pot Springs, White River Plateau, 10,000 feet), I found *G. lygdamus* to be about ten times as common as *L. heteronea*; the latter was ecologically sympatric with the former and could not be distinguished in the field.

If this is found to be a true case of mimicry, it is apparently the only one among butterflies involving only the male (the female *L. heteronea* is a typical copper). Other cases of Batesian mimicry in butterflies are restricted to the female, or both sexes are involved (Ford, op. cit.). Also of interest is that *L. heteronea* is nearly allopatric with another blue mimic (*C. caerulea*), overlapping only in eastern California (Downey, op. cit.). Additionally, the several species of lupine feeding blues may form a large Müllerian complex.

I hope that these observations will stimulate further research on mimicry in these butterflies, both in the field and the laboratory. For example, I have seen remains (wings) of blues at mud puddles. It would be of interest to have counts of each species represented and to compare these with their abundance.

I thank W. L. Nutting for comments on the manuscript. Collecting in Colorado was supported in part by an N. S. F. undergraduate research assistantship through the Institute of Arctic and Alpine Research of the University of Colorado.

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#### THE USE OF CHLOROETHANE FOR IMMOBILIZATION OF FIELD SPECIMENS

Chloroethane (ethyl chloride) is a colorless, volatile liquid used in the medical profession as a topical anesthetic. Its low vapor pressure causes quick evaporation at normal atmospheric temperatures and cooling of any object in contact with it.

In 1969 I began using chloroethane to "freeze" butterflies caught in the field. The spray is easily directed at the specimen in the net and almost immediately immobilizes it. Although many species do not regain activity after adequate immobilization, a killing jar is still used because some species do become active several minutes post-exposure.

The chloroethane immobilization allows for better specimens to be brought back from field collecting. It lessens the battering of specimens in net and killing jar and prevents their escape in the transfer from the net. The substance has not caused any residue on wings or any pigmentation changes in any species to date.

Chloroethane is supplied in four-ounce glass bottles with fine, medium or course nozzles. I have found the fine nozzle to be adequate for most Lepidoptera and the medium nozzle to be adequate for even the largest. The four-ounce fine nozzle will do 250-300 specimens and the medium nozzle 150-200 specimens. If the bottles are stored in a refrigerator when not in use the chloroethane evaporates very slowly and may be used over many weeks with almost no loss between usages. I have found that wrapping the bottle in crumpled tinfoil is also useful. This acts as an insulator, keeping the fluid cooler longer, lessening evaporation and so allowing the chloroethane to be used for more specimens. The tinfoil also protects the glass bottle from breakage should it be dropped.

The main disadvantage to chloroethane is that it is flammable. It burns with a light green flame and liberates hydrogen chloride as a by-product. Except for the flammability, chloroethane is a relatively safe chemical when compared to other poisons used in entomology.

Chloroethane is a prescription drug and some difficulty may be encountered in obtaining it for non-physicians. Presently it may be obtained only from hospital pharmacies with a prescription from a physician. If sufficient interest is expressed from collectors, manufacturers may make it available to biological supply houses for use in entomology.

RAYMOND CASTILONIA, *Loma Linda University, Loma Linda, California.*

MIDGES SUCKING BLOOD OF CATERpillARS  
(DIPTERA: CERATOPOGONIDAE)

Lepidopterous larvae have been known to be attacked by bloodsucking midges since De Geer (1752, *Mem. Hist. Insectes* 1: 327) wrote, "Nos grandes Chenilles sont aussi incommodées par ces petits Mouchérons; sur le corps d'une de ces Chenilles j'en vis cinq ou six, qui avoient enfoncé leur petite trompe dans la peau, & oui étoient occupés à sucer la liqueur verdâtre, qui est le sang de la Chenille." In all the lepidopterous literature appearing in the two hundred years since that time, however, there are so few accounts of these tiny parasites that it would appear that they are extremely rare. I believe that such is not the case, and that these midges have been overlooked because of their small size (less than 2 mm long), their rapid darting flight, and probably their nocturnal habits.

In 1956 (*Ann. Ent. Soc. Amer.* 49: 356-364) I reviewed all the published records and available museum specimens of these caterpillar parasites and concluded that all pertained to *Forcipomyia fuliginosa* (Meigen), a common species with nearly world-wide distribution. I have just finished going over the museum material and literature again, and although I can now recognize several distinct local species of caterpillar parasites in tropical America, *F. fuliginosa* still remains as the main species attacking lepidopterous larvae around the world. It also occasionally attacks other soft-bodied insects such as sawfly larvae, dragonflies, and meloid beetles.

Several observers have noted outbreaks of these bloodsuckers in sufficient numbers to indicate that on occasion they may have a role in reducing caterpillar populations. Hagen (1883, *Ent. Mo. Mag.* 19: 254) called attention to their attacks on *Pieris menapia* Felder in Washington Territory, and Baker (1907, *U.S. Dept. Agr. Bur. Ent. Bull.* 67: 117) reported their depredations on an outbreak of *Melanchroia geometroides* Walk. in Cuba. Mayer (1955, *Ztschr. für Ang. Zool.* 1: 95-107) suggested that the death of the caterpillars was probably not caused directly by the feeding of such small midges, but that their habits fitted them well to act as vectors of polyhedral viruses or other diseases.

The purpose of this note is a plea to lepidopterists to make a special effort to look out for these minute caterpillar pests during their field work. I suspect that night-time observations might give us more data on the abundance of these midges and their habits. In some situations it is very possible that these tiny flies may have some role in biological control, particularly in bringing a virus infection from "wild" hosts in a field or orchard margin into a caterpillar population on a crop plant.

WILLIS W. WIRTH, *Systematic Entomology Laboratory, ARS U. S. Department of Agriculture c/o U. S. National Museum, Washington, D. C. 20560.*

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NOTES AND NEWS

It is a pleasure to announce that Dr. Alexander B. Klots and Dr. Eugene Monroe have been overwhelmingly approved by the membership as honorary life members of the Lepidopterists' Society.

The new editor of the *Journal* asks that prospective authors carefully read the NOTICE TO CONTRIBUTORS (inside back cover), as several changes in editorial policy have been instituted.

## OBITUARY

## PERCY HEATH HOBART GRAY

1891-1971

It is with deep regret that we record the death on October 11th, 1971, of Dr. P. H. H. Gray, a Charter Member of the Lepidopterists' Society, and for some years a member of the Entomological Society of Canada and the Entomological Society of Quebec.

He was born in Woodland Heights (Richmond), Virginia, on November 21st, 1891, and studied in England at Oxford, (M.A.) and London University (D.Sc.). In 1920 he joined the staff of the Bacteriology Department, Rothamsted Experimental Station, England, and in 1929 became Professor and Chairman of the Department of Agricultural Bacteriology, Macdonald College of McGill University, Ste. Anne de Bellevue, P.Q., Canada. During the course of almost 30 years prior to his retirement in 1957, his research output was considerable, concerning mainly the activities of soil microorganisms towards cellulose, urea and pesticides and a great many scientific papers were published in this connection. For many years Dr. Gray guided numerous students who trained in microbiology and who now hold important positions across Canada.

During this period, Dr. Gray found time for and took a great interest in entomology, developing a good local collection of Lepidoptera, collected for the most part in his garden at Baie d'Urfe, P.Q., and in the surrounding woods and fields. His careful collecting produced several species not previously recorded for the Province of Quebec. He published some 25 papers on Lepidoptera. He was also a proficient classical scholar, and his quiet wit was at its best in many verses which he composed and in his letters to friends.

Shortly after retiring he moved to Nova Scotia, purchasing a home outside Digby, where he resided and continued with his interest in entomology until the time of his death. Our deepest sympathy is extended to his wife and son.

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Address all correspondence relating to the *Journal* to the editor. Material not intended for permanent record, such as current events and notices, should be sent to the editor of the *News*: Dr. C. V. Covell, Department of Biology, University of Louisville, Louisville, Kentucky 40208.

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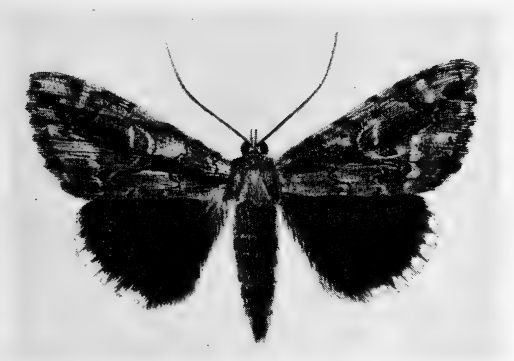
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### *Memoirs of the Lepidopterists' Society*, No. 1 (Feb. 1964) A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA

by CYRIL F. DOS PASSOS

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Color Plate. Examples of freeze-dried larvae (natural size). 1. *Eacles imperialis imperialis* (Drury), on *Liquidambar styraciflua*, L. 2. *Callosamia securifera* (Maassen). 3. *Darapsa myron* (Cramer), on *Vitis* sp. 4. *Hyalophora cecropia* (L.), on *Liquidambar styraciflua*, L. 5. *Eumorphia fasciata* (Sulzer), on *Ludwigia leptocarpa* (Nuttall).

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## PRACTICAL FREEZE-DRYING AND VACUUM DEHYDRATION OF CATERPILLARS

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The purpose of this paper is to describe a method of preserving larvae of Lepidoptera and other soft-bodied insects whereby a lifelike appearance can be maintained, the process completed in a short time, the internal anatomy preserved, and the required equipment purchased within the budget of a small laboratory, even of the make-shift variety.

Papers on the subject have been published by Meryman (1960, 1961), Blum & Woodring (1963), Woodring & Blum (1963), and Harris (1964, 1968). But the equipment used by these workers is rather involved and expensive. Flaschka & Floyd (1969) developed a method that requires only a tightly stoppered jar with desiccant, and a home freezer. But the simplicity and low cost are countered by extremely long drying times. The method described here combines a minimum of drying time with an intermediate cost of a few hundred dollars or less. The description will be given in such a way that alternatives and modifications may be applied that allow further reduction of the expenses. For example, the two-stage vacuum pump rated at a vacuum of 0.1 micron is ideal, but a cheaper pump will be found satisfactory as long as it will pull down to about 100–200 microns. The degree of vacuum is one of the factors that has a direct bearing on drying time. The gas ballast recommended for museum systems is unnecessary here because of the relatively small amount of moisture encountered. In any case one must try to be sure that water vapor is not permitted to reach the pump oil, and the purpose of a gas ballast is to remove large quantities of water vapor without damage to the pump. By the same token, dirty oil should be changed.

Provided the specimens are in close enough proximity to the desiccant (or vapor trap) to lie within reasonable reach of the mean free path of the water vapor molecules, several factors influence the time required

for, and the efficiency of, the drying. The two most important are temperature and degree of vacuum. Their appropriate choice allows manipulation of the process within wide ranges. The method of Flaschka & Floyd (1969), while simple, effective and inexpensive, cannot provide much leeway. The temperature of a home freezer is fixed and usually slightly lower than ideal, and no vacuum is applied. Consequently a drying time of about 100 days for a medium sized larva (e.g. *Malacosoma americanus*) results. Appropriate selection of temperature and vacuum can improve the situation to a remarkable degree. With a vacuum of 0.1 micron at 25° F., such a caterpillar will be adequately dry in 48 hours, finishing off for a few hours at room temperature. In general the specimen should be frozen before applying vacuum to prevent distortion in the freeze-dry process, and I have found the ideal temperature to be about 20–25° F. rather than the lower temperatures recommended in the literature. Such temperature guarantees that the frozen state is maintained while leaving leeway for opening the freezer door, but is not so low as to seriously curtail the rapidity of molecular motion. In principle there is a slight cooling effect due to the sublimation process itself (similar to the cooling experienced when water evaporates from one's skin), but the heat exchange involved is so small that the phenomenon can be disregarded. It becomes a factor of importance only when working with large museum specimens (mammals, reptiles, etc.) where it is one of the conditions that lead to prolonged drying time.

### Some Theoretical Considerations

The following discussion is presented in the hope that it may give the reader enough understanding of the underlying processes to help him perform the job more efficiently and enable him to use his ingenuity when adapting the method to his own needs and budget.

Water in both liquid and solid form (ice) exerts a vapor pressure that is a function of the temperature. This means that if brought into a confined chamber, water or ice will evaporate and increase the total gas pressure by an amount equal to the vapor pressure at the prevailing temperature. In relation to the total gas pressure present, one refers to the partial pressure of water vapor. It is important to realize that this concept holds only as long as there is some water or ice still left. Then, when the required partial pressure is reached, a state of dynamic equilibrium is established; in other words, the number of water vapor molecules per unit time evaporating from the surface of the water or ice is exactly equal to the number of molecules condensing on that surface from the gaseous phase. If water vapor is removed from the chamber (e.g. by pumping out, freezing out, or binding on a drying agent) more water vapor will evaporate in order to restore the partial pressure to the level dictated by the temperature. The more molecules of other gases present (air), the more difficult it is for the molecules evaporating from the water (or ice) to dissipate; then a state of quasi-saturation will be reached near the water (or ice) surface and further evaporation will cease. If, however, a vacuum is applied and the air molecules removed, the evaporation of water and dissipation of its vapor can proceed with less obstruction, and thus more efficiently. It may be noted in passing that no gases other



than water vapor are produced from the specimen by the drying process in sufficient quantity to merit serious consideration. A further process is involved, namely that of bringing the water from within the specimen to the surface where it can evaporate. This process is called diffusion, and its rate is a function of molecular motion and thus also of temperature.

So one tries in freeze-drying to operate at as high a temperature as practical while still keeping at all times below freezing. In vacuum dehydration, one depends on the internal pressure of the specimen, the comparative toughness of the integument, and the rapidity of drying for the maintenance of the shape of the specimen, though in this latter process there is the inherent danger of overstretching.

For a closer look at this situation it is helpful to introduce the concept of the *mean free path length*, which is defined as the average distance a gas molecule can travel before colliding with another gas molecule (bumping into the wall does not count as a collision). The mean free path length depends, therefore, on the extent of evacuation (of air). For water vapor at a pressure of 10 mm Hg the mean free path is 0.0034 mm; at 10 microns, it is 3.4 mm; at 1 micron it is 34 mm (Meryman, 1961). It can thus be seen that in either system the advantage of operating in a vacuum is enormous. If the vacuum is adequate, water vapor molecules leaving the drying specimen can travel almost without obstruction to the desiccant where they are held.

It should be kept in mind that the sole function of the pump is to create a vacuum rapidly and efficiently. Once the vacuum is attained the stop-cock (G) is closed to keep the leak-proof desiccator evacuated, and the pump is shut off. It does *not* run continuously in order to pump out the water vapor as it forms, nor does it circulate an air stream which carries away the humidity. The drying of the specimen is achieved exclusively by the molecular motion of the water vapor passing from the specimen to the desiccant.

### The Desiccant

While in theory the cold trap removes water vapor from the specimen more efficiently, the equipment and operation are considerably more complex. A desiccant is perfectly adequate for the purpose at hand. Silica gel ( $\text{SiO}_2$ ) or calcium sulfate ( $\text{CaSO}_4$ ) impregnated with an indicator such as cobalt chloride do very well. Both chemicals with the indicator are blue when able to adsorb water and pink when exhausted. Both can be regenerated by spreading in a pan and drying in an oven at about 350–400° F. for about 2 hours. Calcium sulfate is the slightly more effective drying agent but silica gel will be found equally satisfactory. It is advisable not to mix the two agents because much of the efficiency of the more effective of the two will be lost, since it will first dry out the less effective, until finally the higher vapor pressure dictated by the latter will prevail. It is preferable to use the desiccant in granules of about #8 mesh (roughly 3–5 mm in diameter). Smaller granules are difficult to manage cleanly, and a certain amount of fine dust is produced in any case which must be kept off the greased portion of the desiccator and its lid (a ring of paper cut to size and laid on the greased surface helps), otherwise the vacuum will not hold. The dust should also be wiped from the inside of the vessel to prevent the formation of a deposit on the specimen that may be difficult to remove.

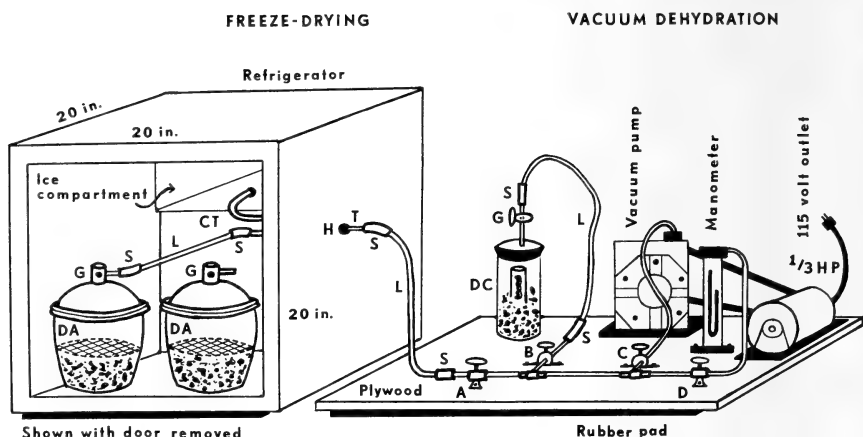


Fig. 1. Apparatus for freeze-drying and vacuum dehydration. Explanation in text.

Replenishment of the desiccant may be necessary before the caterpillars are dry if they are large or numerous. A freshly charged desiccator should be on hand in the freezer and the transfer of specimens accomplished with reasonable rapidity so that no thawing occurs. It is generally best not to put too much material in the works at one time. Meryman foresees in an unpublished paper the difficulties likely to beset the over-enthusiastic student who might be tempted to freeze-dry specimens the size of a physics professor, leading to excessive drying time and inferior results.

### Basic Equipment

My equipment (Fig. 1) consists of a small (20 × 20 × 20 inch outside measurement) standard refrigerator with its normal ice-making compartment. By dint of wrapping a bit of tape around the capillary tube (CT) of the thermostat in the ice-cube compartment, the temperature of the whole refrigerator can be lowered to about 20° F. A hole (H) is drilled through the wall of the refrigerator (but *not* leading into the ice-cube compartment nor any other place where damage to the refrigeration coils might result). Through this hole is passed a length of copper tubing (T) of ¼ or ⅜ inch outside diameter, which is then firmly fixed (e.g. epoxy glue or bracket) to the refrigerator wall. The outside diameter of the tubing must closely approximate that of the glass tubing of the stopcocks (G) in order to achieve air-tight connections. This length of tubing (T) is extended about an inch inside the refrigerator, sufficient to attach a short sleeve (S) about 2 inches long of tightly fitting heavy flexible plastic tubing. A piece of plywood is placed alongside the refrigerator, and

securely and permanently fastened thereto are the vacuum pump and manometer, the vacuum-tight brass line valves, and the permanent connecting copper tubing and fittings; these include such additional hook-ups as may be wanted to perform the vacuum dehydration (B). A rubber mat under the plywood will absorb any vibration from the pump and cushion any screws or bolts appearing on the under surface of the plywood.

It is worth emphasizing that all joints and valves, stop-cocks and desiccator lids—in other words the entire system—must be as absolutely leak-proof as possible at high vacuum. Silicone grease, or even vaseline, on meticulously cleaned stop-cocks, desiccator lids, and around the joints connected by the plastic sleeves (S), will help ensure tight fits. The permanent copper joints depend on proper flaring for sealing; but Duco cement or similar sealer will help after the joints are made. Teflon sealer on any screw-in joints (as with the manometer) likewise is of advantage. Not shown in the figure, but easily incorporated if desired, are filters (glass wool is a good material or vacuum filters may be purchased) to prevent foreign material from entering valves or pump.

Various vacuum gauges are available which give accurate absolute readings, such as the McLeod or Pirani gauges. A simple double column U-shaped mercury manometer is cheaper and fully adequate since an absolute reading is unnecessary. When the two columns of mercury become stabilized in relation to one another, the system is evacuated as far as it will go. One can judge the degree of vacuum achieved by assuming an approximation of the manufacturer's rating of the pump employed. Valve (C) leading directly to the pump is then closed, and any leak will be registered in degree according to the rapidity with which the mercury column moves. It is a good practice in any case to check the vacuum in the desiccators periodically to be on the safe side. A well-sealed desiccator, of course, can be evacuated and after closing stop-cock (G) be removed from the system to be replaced by another desiccator containing another lot of specimens.

I have used four types of desiccators, all of which hold both specimens and desiccant. The first (Fig. 1) is a sleeve-top desiccator made of heavy "Pyrex" glass (DA) whose sleeve-top incorporates a stop-cock (G) with hose connection. They come in different sizes and the small refrigerator shown will easily accommodate two of the 8-inch diameter vessels. The bottom is filled with desiccant, and a disc (or preferably a shallow basket) of fine screen wire cut to size is placed over the chemical. The lid and stop-cock of this desiccator require greasing. A second type of container is made of polycarbonate plastic with a rubber gasket beneath its

lid. The lid is made of opaque plastic and contains the outlet for the stop-cock. It is slightly taller than the first, and the gasket, being rubber, must not be greased. It is available from the Nagle Sybron Corporation in Rochester, New York. Both these containers are very satisfactory, being large enough to contain foodplant as well as larvae, and holding the vacuum well. A third type of desiccator is also commercially available and is the drying unit for "Drierite," a trade name for calcium sulfate. It is sold containing a charge of the desiccant labelled as approximately 1½ lbs. of #8 mesh calcium sulfate with a capacity for 50 grams of water. It is made of "Plexiglas" and contains its own filter. After slightly widening the spring coil attached to the metal screw-on top, one can insert one of the plastic pill vials readily available at any pharmacy. The vial contains the larva, and its open end is covered with a bit of cheesecloth fastened on by a rubber band. The vial is inserted into the desiccator so that the open end is in almost direct contact with the desiccant. The metal top with its rubber gasket (ungreased) is tightly replaced, and a stop-cock is added to the lower tubing connection while the upper tubing connection remains sealed, and the unit attached to the vacuum system as before. The purpose of the plastic vial, as well as of the screen wire in the previous examples, is to prevent the specimens from becoming indented by loose granules of desiccant or other matter, a phenomenon which can occur even when the larva is thoroughly frozen. Still another desiccator (DC) can be home-made from any thick-walled wide mouth jar, say about 8-10 inches high. It is a good idea to wrap it carefully with transparent tape to prevent fragments of glass from flying around in case of an implosion. The mouth of the jar is fitted with a heavy bevelled rubber stopper into which a hole has been bored for the snug fit of one arm of a glass stop-cock (G). Again, the jar is partly filled with desiccant and the specimen(s) within the vial inserted as before and the vacuum applied. Desiccators must, of course, be transparent so that it is possible to watch both the specimens and the color of the desiccant.

Whichever desiccator is used, it is a good idea to keep two in the freezer ready for immediate use. In operation, the outlet from the stop-cock (G) receives a short tight sleeve (S) of the flexible plastic tubing, in turn connected by a suitable length (L) of copper tubing to the fixed end of the tube (T) that runs into the freezer. The other end of tube (T), of course, ends up at the pump. Attaching any desiccator to the vacuum system is reduced to simplicity itself by the use of an intermediate length of copper tubing (L) of any length and curvature desired, connecting it by the sleeves (S). Any desiccator must be able to withstand a little pressure of up to one atmosphere, and some may be

ordered that can be fitted with a steel wire screen that acts as a guard against flying fragments in the event of an implosion.

Outside the freezer, a small number of line valves are added. One (A) is located near the end of the copper tubing leading to the freezer. Another (B) is located at such point as a vacuum dehydration line is desired. It may be found advantageous to have two or more of these. Valve (C) shuts off the pump alone, for the pump, when not in operation, will gradually bleed air back into the system and this valve allows the pump to be segregated from the entire system while leaving the manometer connected. The last valve (D) shuts off the manometer alone. Its purpose is to protect the manometer. This valve should be left either just cracked open, or closed and used only when actually measuring the vacuum. Otherwise a sudden loss of vacuum in the system (as may easily happen if one forgets to shut off the appropriate valve when removing a desiccator) may cause the mercury to blow through its glass top.

### Procedure

Let us now proceed through a freeze-dry operation step by step. First one must kill the larva. While this can be done in boiling water, a cyanide jar or by other methods, I prefer to place it in some suitable container and simply let it freeze for two hours or so. One can let the caterpillar crawl along its foodplant, and with luck and if the animal is not too active, it *may* remain grasping the leaf or stem in a natural posture. Should it freeze in an undesirable position, let it thaw sufficiently (including its interior) before attempting to manipulate it, or the specimen will crack. Then refreeze it in such position as you choose. The desiccator is assumed to have been prepared and below freezing. The weight of the frozen larva is quickly recorded on a balance that will weigh to about  $\frac{1}{10}$  of a gm. One can thus later determine the point at which a weight loss of 75% is reached. This represents approximately 90% of the total water content, and at this point the process is sufficiently advanced to allow removal and permanent storage in the collection. Since the ambient air always contains some moisture, the desiccator should not be opened until it has warmed to room temperature. Otherwise contact of the frozen larval surface with the warm moist air will be apt to ruin the appearance of the specimen. I make it a practice to leave it thus at room temperature, i.e. in a state of vacuum dehydration, for 24 hrs. One can hasten this process by use of a heat lamp provided the heat is administered with restraint. Of passing interest is the fact that about 5% of the water content of the larva is chemically bound, and therefore unavailable for evaporation. After a bit of practice it will be possible to judge with reasonable accu-

racy when the specimen is ready without having to bother with weighing every individual.

The frozen specimen is placed in the desiccator after weighing, the lid tightly sealed, and the container returned to the freezer, connected to the vacuum line, and the vacuum applied. The weighing and transfer of the larva should of course be accomplished as rapidly as possible so as not to allow thawing. When the vacuum pull-down is complete, close Valve (A) and the stop-cock (G), disconnect the desiccator from the system and move it to another part of the freezer in order to be ready for the next desiccator. During the drying process keep a check on the vacuum, and on the color of the desiccant, replacing the latter if necessary. If the foodplant is to be included as well, it too is preserved by the process. Contrary to what one might expect, dried specimens will not resorb water even in a humid climate, but it is important to remember that they are attractive to pests such as dermestids—and even to squirrels, as one collector discovered to his distress.

Another possibility is illustrated by the case of a caterpillar that has been attacked by a stink bug or other sucking creature. One can hasten to place a flaccid carcass of this sort, if fresh, in a desiccator without prior freezing and apply the vacuum. The empty skin will expand just like a toy balloon. A larva that has sickened and become flabby can sometimes be preserved in a similar manner. If there is danger of overstretching, the vacuum may be held at any desired level by closing the stop-cock and letting the specimen freeze at that level of vacuum. Then, when thoroughly frozen, full vacuum may be applied.

If a spreading board is cut into sections short enough to fit into a desiccator, the occasional mounted butterfly or moth can be rapidly dried. Often their abdomens may be soft and tender, so to avoid unsightly expansion freeze-drying is the method of choice. I have successfully applied this method on occasion to fresh specimens during the course of photographing plates for *Moths of America North of Mexico*, when a freshly caught specimen happened along that could be used to better advantage than the museum specimen originally chosen. There is scope for numerous experiments of this sort.

Meryman (1960) recommends that freezing be done at modest temperatures as in a home freezer, rather than at very low temperatures. Such relatively high temperatures cause the water content of the larva to freeze in large extracellular crystals that easily sublime. As they grow, water is removed from both intracellular and extracellular locations without damage to the tissues or cells. Sudden very deep freezing will cause the formation of small intracellular crystals as well, causing possible

histological damage and increasing the drying time due to a slower rate of sublimation. However, the quick-freeze method provides the outstanding advantage of ensuring a lifelike position on the foodplant as shown on the color plate. Liquid nitrogen (used by cattle breeders among others) may be tried (temperature  $-320^{\circ}\text{F.}$ ) provided one is familiar with the proper procedures and precautions. Or one can use dry ice (temperature  $-110^{\circ}\text{F.}$ ) in alcohol or other compatible liquid, or a low temperature freezing unit. Another good agent is a quick-freeze aerosol such as ethyl chloride, or "Cryokwik" (a trade name for an aerosol mixture of fluorinated hydrocarbons).

Some of the larger larvae have comparatively thick integuments, and as the integument dries it presents an ever-increasing barrier to the passage of water vapor molecules from within the specimen to without. However, with a fresh larva the increase in drying time is negligible, and such large caterpillars as *Hyalophora cecropia* or *Citheronia regalis* will be well dried in 72 hours. It has been reported by Blum & Woodring (1963) that larvae frozen for weeks or months without attention to drying tend to distort and toughen, thus making the process less satisfactory. In such cases, as with the tough covering of pupae, holes punched through the integument will shorten the drying time. The same authors state that some, but not all, greens eventually tend to fade or change color due to chemical differences in the chromatophores. So far in the year and a half I have used this process, no noticeable change has occurred, but only time will tell.

Vacuum dehydration, which is carried out at room temperature, will be found satisfactory at times, and here the selection of appropriate specimens is of importance, as thin-skinned insects will stretch or even burst. The two advantages of this method are the greater speed of drying and the fact that no freezer is required. As a practical matter one can discount the latter since the majority of specimens will turn out more satisfactorily if freeze-dried at least in the initial stages of the procedure. With vacuum dehydration, of course, the vacuum is essential, since the drying process must proceed more rapidly than the enzymatic activity which at room temperature promotes rapid putrefaction.

As for pinning the specimens, an anal wire wrapped around a pin may be used as is usually done with inflated larvae; or a pin may be inserted directly through the dorsum after drying. A drop of cement is generally required for stability. As a rule, specimens should not be pinned before drying, as chemical action in some cases will tend to cause a dark spot around the pin. On the other hand, some very small larvae will have to be pinned while only semi-frozen since they may break when dry.

Larvae prepared by either process can be reconstituted for dissection or histological study (Van Cleave & Ross, 1947; Harris, 1964). To quote from a personal communication to the author from Mr. Harris: "We used from 0.5% to around 2% tribasic sodium phosphate and usually incubate at about 37° C. Be careful not to overdo things. I would point out the following: As far as histology is concerned it should not be necessary to use the reconstituting agent as no shrinkage should have taken place, and all that is necessary is to place the specimen in a warm preservative for the usual process of dehydration and embedding, etc. However, there are times when one is not quite sure and it may be safer to use the agent before further treatment. If you are able to look at a copy of *Man*, an article by A. Sanderson on *The Study of Mummified and Dried Human Tissues* published about 1959, you will find many interesting points that could be applied to entomology, etc." I myself have not yet attempted reconstitution.

I shall close by wishing the reader many happy hours with flaring tools and wrenches, and success in his endeavours.

#### SUMMARY

The principles involved in both freeze-drying and vacuum dehydration lie in the permanent removal of water vapor that evaporates from the tissues of the specimen. A method is presented of setting up a reasonably flexible apparatus on the basis of equipment at a cost that should be within the reach of most small laboratories and many private collectors. I have confined myself to the more practical matters with enough theory to enable the reader to gain a reasonable understanding of what he is doing in order to prepare natural and lifelike specimens of larvae and similar insects, and to enable him to use his own ingenuity in improving or varying the apparatus according to his inclination, needs and budget. One or two theoretical matters are mentioned that are not applicable to the system described, because they will be found in the literature and might cause confusion when so encountered.

#### ACKNOWLEDGMENTS

I should like to extend my warm thanks to Dr. Hermann A. Flaschka, who has given much enthusiastic help and has steered me safely through some of the more dreadful pitfalls of physical chemistry. He has also taken considerable time, effort and care in reading the manuscript and has offered much by way of constructive criticism. The helpful cooperation of my colleague, Charles R. Edwards, is also appreciated. He shares in the daily work in the laboratory and grins over my shoulder and comes to the rescue when my own machinations with valves, wrenches and



plumbing end up in disaster. I should also like to extend grateful thanks to Mr. R. H. Harris, of the Experimental Laboratory of The British Museum (Natural History) in London, for the cheerful, stimulating and willing help and advice he has shared from his store of expert knowledge concerning the processes described.

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### A NEW SPECIES OF THE GENUS *PYROMORPHA* HERRICH-SCHAEFFER (PYROMORPHIDAE)

ANDRÉ BLANCHARD

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Some male specimens of this species have been in my collection for over five years. I have delayed describing it, hoping that I would take at least one female. In this I have been disappointed. As I have a sizeable series of males I am offering this description of it.

#### *Pyromorpha caelebs* A. Blanchard, new species

**Male** (Fig. 1): Head black, closely scaled, except on vertex where some long scales project forward between antennae or lean against their scapes. Tongue strong. Labial palpus short, filiform. Maxillary palpus vestigial. Antenna bipectinate, of about 35 segments, black, closely scaled above; each pectination slightly swollen near apex, tapering to base, bearing two rows of cilia. Collar, thorax, patagiae and abdomen black. Legs slender, closely scaled, black except yellow inner side of foreleg, some yellow scales distally on midfemur; one pair of terminal, rudimentary spurs on mid

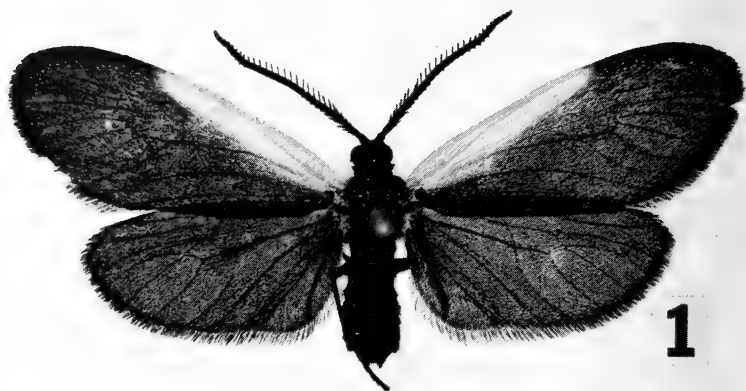


Fig. 1. *Pyromorpha caelebs*, Holotype.

and hindtibiae. Forewing above thinly scaled, semitranslucent, black except for ochreous-yellow fascia anteriorly limited on costa, posterior limit of which extends along basal two-thirds of cubital vein, slides in cell to radial vein, and follows  $R_1$  to costa; distal half of fascia well defined, basal half less definite because of sprinkling of yellow scales between cubital and first anal veins; fringe consisting of somewhat irregularly planted, bluish-black, narrow scales. Hindwing above black; very light and narrow sprinkling of yellow scales along costa; fringe similar to that of forewing. Forewing beneath as above, posterior margin of yellow fascia more diffuse. Hindwing beneath as above except for well-marked, yellow fascia between costa and discal cell. Venation of wings as shown in fig. 2;  $R_3$  and  $R_4$  of forewing either separate or connate.

Length of forewing: 10 to 12 millimeters.

Genitalia: As represented in Figs. 3, 4 and 5. Uncus absent or possibly represented by mucrones on each half of tegumen; these separate except where they meet strongly sclerotized gnathos. Juxta oval with small indentation under aedeagus. Dorsal part of anellus a complicated assemblage of two spiny pads, one on each side of aedeagus, tied together back of it by narrow transtilla, supported on each side from ninth abdominal segment by two sclerotized, contorted arms.

Female: Unknown.

Holotype: Male, Fort Davis, Texas, Hospital Canyon back of Historical Fort, 18 May 1971, deposited in the National Museum of Natural History. Type n°. 71981.

Paratypes: (All males). Fort Davis, Texas, Hospital Canyon, 17 May 1966, six; 11 June 1969, ten; 18 May 1971, thirteen. Davis Mts., Mt. Locke, McDonald Observatory (6700'), 25 May 1968, four; 10 June 1969, five. Fort Davis, one mile north of city near Limpia Creek, 21 May 1971, four. All these paratypes collected in 15-foot fluorescent traps by A. and M. E. Blanchard. Paratypes will be deposited in the National Museum of Natural History, the American Museum of Natural History, and the British Museum (Natural History). Some will remain in my own collection. There is in the National Museum a specimen labeled only "Kerrville, Texas" which I believe to be conspecific; but it was never spread, its wings are wrinkled and, although Kerrville would be an interesting location, I prefer not to make it a paratype.

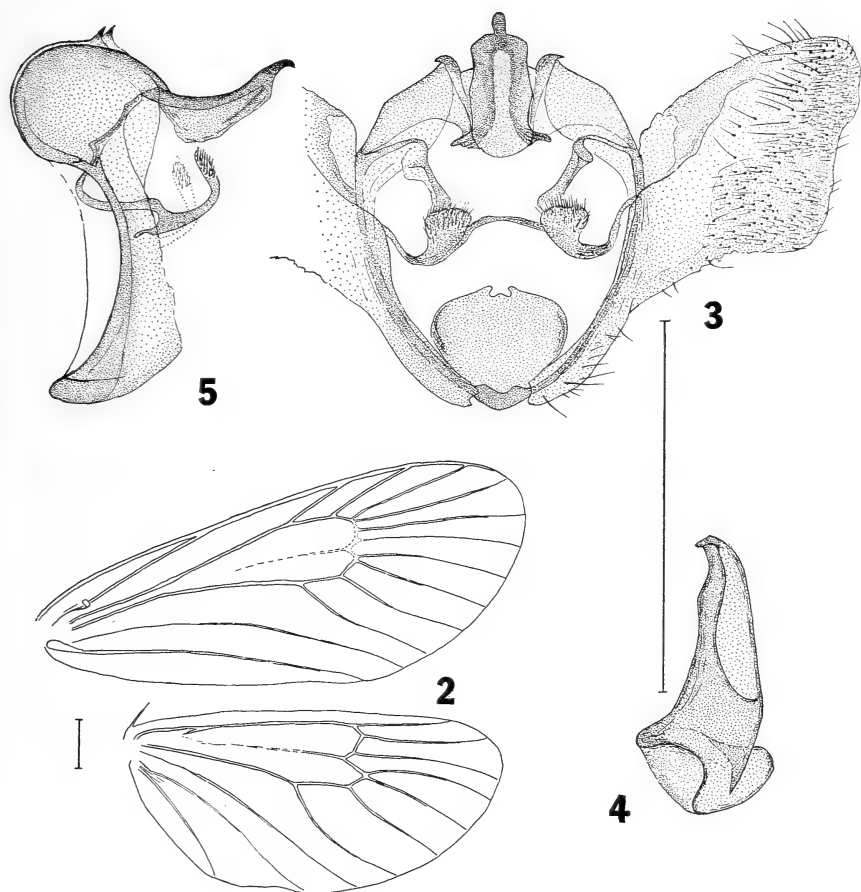


Fig. 2. Venation of wings; Figs. 3, 4 & 5: male genitalia: 3, posteroventral view, valves widely open, aedeagus omitted; 4, aedeagus, lateroventral view; 5, left side view, valves and aedeagus removed. The linear segments represent one millimeter.

The male of *Pyromorpha caelebs* is close to that of *P. dimidiata* Herrich-Schaeffer (1855). They are about the same size and the colors of the background and fascia are close. They can be separated by the following combination of characters: The costa of the forewing of *caelebs* is nearly straight in its basal two-thirds, that of *dimidiata* is much more arched. The forewing of *caelebs* is narrower; the ratio of its length to its midwidth being approximately 2.5 instead of about 2.25 for *dimidiata*. The radial veins  $R_3$  and  $R_4$  of the forewing of *caelebs* are either connate or separate instead of shortly stalked. The ratio of the length of the longest pectinations of the antenna to the width of the flagellum is about 2.5 instead of

about 4; the flagellum is also somewhat stouter. The yellow fascia of *caelebs* is narrower because the costa is less arched, and in its basal half it barely exceeds the cubital vein instead of following the first anal all along its basal half. It is difficult to define exactly how the genitalia differ; the juxta of *caelebs* is oval or very slightly cordate, that of *dimidiata* definitely cordate (concave lateral margins); the gnathos is longer and its base narrower, but the great thickness of the genitalia relative to their width makes it difficult to present on a single conventional preparation a satisfactory view of all the organs and particularly the gnathos.

#### ACKNOWLEDGMENTS

I wish to thank the administration of Fort Davis N.H.S. for the authorization to collect in Hospital Canyon and Mr. Curtis D. Laughlin for letting us set our traps at Mt. Locke on the McDonald Observatory grounds. I am grateful to Dr. R. W. Hodges for his interest and help and for revising the manuscript.

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HERRICH-SCHAEFFER. 1855. Samml. aussereur. Schmett., Pl. 43, fig. 222.

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## THE LIFE HISTORY OF *SCHINIA CITRINELLUS* (NOCTUIDAE)

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*Schinia citrinellus* (Grote & Robinson, 1870, p. 180) feeds in the larval stage on *Croton californicus* Muell-Arg. *C. californicus* is distributed from southern California to Arizona (Munz, 1963), but *citrinellus* occurs from the southern California deserts eastward at least to central Texas (Brazos Co.), so presumably other species of *Croton* serve as its food plant in the more eastern areas of its range. *Schinia citrinellus* has two annual flight periods, one in the spring and one in late summer and early fall. These probably correspond closely with the blossoming periods of its host plants. The spring flight period on the deserts of southern California extends between the end of March and the middle of June.

#### Behaviour

*Schinia citrinellus* is evidently an exclusively nocturnal species, and no *citrinellus* was noted during daylight hours on the deserts of southern

California at a time when moths were being taken in moderate abundance in a light trap. The eggs are deposited among the small buds or within the partially open buds at the apex of the plant. The rather unusual opaque white eggs of *citrinellus* are difficult to detect in the hairy, pale-grey vestiture of the *Croton* buds.

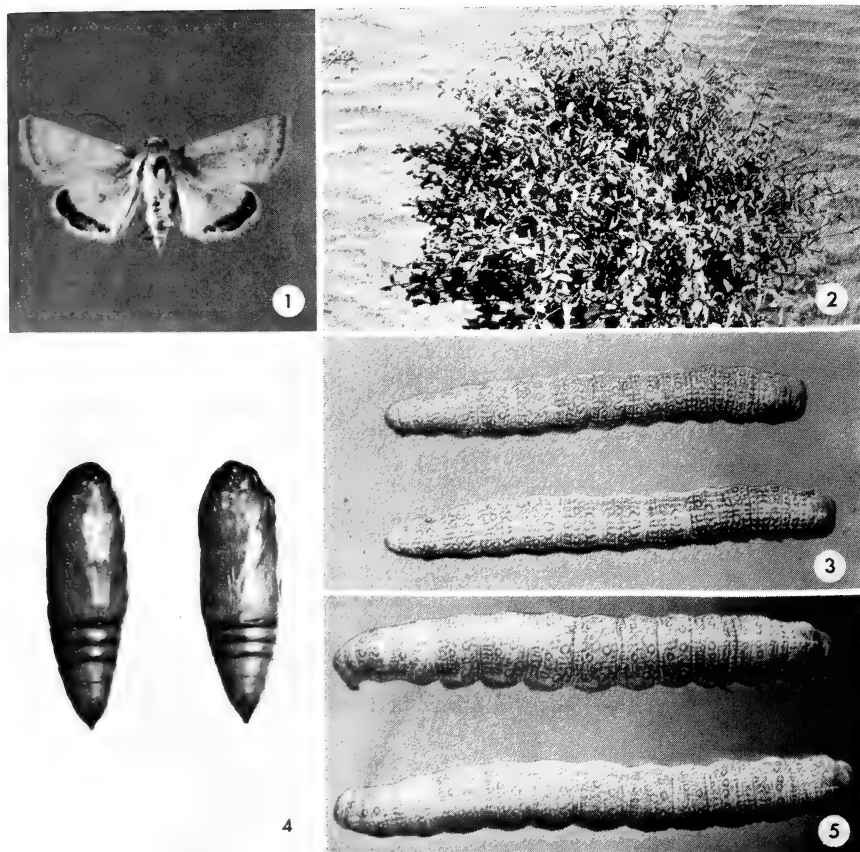
A single wild-caught female deposited a total of 176 eggs in captivity. The majority of these hatched on the fourth day after deposition, a few on the fifth day.

The fully formed larva has the habit of resting for a considerable period after it has chewed an exit hole in the chorion but before it has made its escape from the shell. After freeing itself from the egg, the larva makes its way down through the blossom or bores through the petals of the bud to reach the orange glands located on the surface of the receptacle; the first-stadium larva feeds almost exclusively on these glands. In later stadia, other floral parts are consumed. The small seed capsules are fed on to a limited extent but the more mature stone-like fruits are never attacked. The last-stadium larva feeds preponderantly on the buds, but unlike most heliothidine larvae, will also feed on the leaves of its host plant. At the cessation of feeding, the larva makes its way to the ground and tunnels into the soil to pupate.

### Descriptions of Stages

The ultimate-stadium larva and the pupa of *Schinia citrinellus* have previously been described by Comstock (1931). The immature stages on which the following descriptions are based, constituted the progeny of a single female taken at Thousand Palms, near Indio, California. The durations of stadia listed are those obtained from rearings maintained at room temperature. Rearing techniques employed were those outlined by Hardwick (1958). The estimate of variation following the means for various values is the standard deviation.

**Adult** (Fig. 1). Head, thorax and forewing dull creamy-yellow; museum specimens often rather intensely yellow as a result of the action of the killing agent. Abdomen cream or creamy-grey. Forewing almost immaculate, usually with a vague dark reniform and subterminal band; these evidently only the transmission of dark markings from the underside of the wing. Forewing usually with a few scattered dark points, the most consistently present being at the apico-costal margin of the reniform spot. Fringe concolorous with remainder of wing. *Hind wing* white with a brown outer-marginal band containing a white median shade; outer band often evanescent near anal angle. A brown discal spot usually present. Fringe white. *Underside of forewing* white with brown orbicular and reniform spots, and subterminal band. Usually a series of brown sagittate marks at outer margin of wing, these occasionally fusing to form a brown marginal band. Costal and outer areas of wing often suffused with yellow. *Underside of hind wing* white or pale cream, often with a brown spot on disc, and another near anal angle of wing.



Figs. 1-5. *Schinia citrinellus* (Grt.) and its food plant. 1, Adult, Palm Springs, Calif.; 2, food plant, *Croton californicus* Muell.-Arg.; 3, 5, dorsal aspect of ultimate-stadium larvae; 4, ventral aspect of pupae.

*Expanse*:  $26.1 \pm 1.4$  mm (34 specimens).

*Egg*. Of a peculiar white opacity unusual in heliothidine eggs; showing little change until a few hours before hatching when mouth parts and head capsule become visible through chorion.

*Dimensions of egg*: length,  $0.593 \pm 0.030$  mm; diameter,  $0.451 \pm 0.033$  mm (20 eggs).

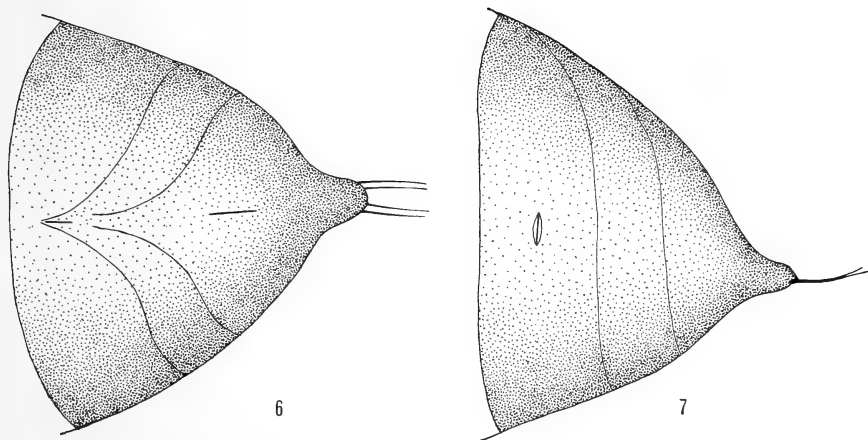
*Incubation period*:  $4.1 \pm 0.3$  days (157 eggs).

*First-Stadium Larva*. Head black. Prothoracic and suranal shields dark smoky-brown. Trunk creamy-grey. Spiracles with light- to medium-brown rims. Thoracic legs medium smoky-brown.

*Head width*:  $0.300 \pm 0.013$  mm (25 larvae).

*Duration of stadium*:  $4.1 \pm 0.3$  days (46 larvae).

*Second-Stadium Larva*. Head pale pinkish-cream, mottled with pale fawn dorsally. Prothoracic and suranal shields white or pale cream, mottled with light green. Macula-



Figs. 6, 7. Apical abdominal segments of pupa. 6, Ventral; 7, right lateral.

tion of trunk well defined. Mid-dorsal band greyish-green. Subdorsal area with white marginal lines and a greyish-green median band. Supraspiracular area greyish-green, usually with a white or pale cream, irregular and broken, median line. Spiracular band narrow, white or pale cream, often discontinuous. Suprapodal area light greyish-green. Mid-ventral area pale grey. Spiracles with light-brown rims. Setae of trunk light brown with white or cream bases; setal bases interrupting maculation of trunk. Thoracic legs pale pinkish-cream.

*Head width:*  $0.558 \pm 0.026$  mm (25 larvae).

*Duration of stadium:*  $3.1 \pm 0.5$  days (46 larvae).

**Third-Stadium Larva.** Head cream, mottled with fawn. Prothoracic shield light green, mottled with cream, and usually with three cream longitudinal lines. Suranal shield light green, mottled with cream or white. Maculation of trunk complex. Mid-dorsal band greyish-green or light olive-green, with a white or cream, often discontinuous, median line. Subdorsal area with marginal white lines and a median band concolorous with mid-dorsal band; median band usually with a discontinuous white median line. Supraspiracular area green, with a discontinuous white median line. Spiracular band narrow, white or cream, occasionally discontinuous. Suprapodal area greyish-green, mottled with white or cream. Mid-ventral area pale grey, suffused with green. Setae of trunk with enlarged cream or white bases that interrupt the general pattern. Spiracles with light- to medium-brown rims. Thoracic legs cream suffused with pale green.

*Head width:*  $0.92 \pm 0.04$  mm (25 larvae).

*Duration of stadium:*  $3.1 \pm 0.5$  days (46 larvae).

**Fourth-Stadium Larva.** Head pale cream, variably mottled dorsally with grey or fawn. Prothoracic shield white or pale cream, marked with dark green; usually a median and a pair of submarginal lines free of mottling. Suranal shield white, mottled with light green. Trunk greyish-green with numerous, frequently irregular and broken, longitudinal white lines; setal bases large and white. Mid-dorsal band medium to dark greyish-green with a discontinuous median white line. Subdorsal area white with a pair of discontinuous, greyish-green median lines. Supraspiracular area green, heavily and irregularly mottled with white. Spiracular band irregular, white or pale cream. Suprapodal area green, of a more greyish appearance than dorsum, mottled with white or pale cream. Mid-ventral area pale grey suffused with pale green. Spiracles with

light-brown rims. Thoracic legs pale cream, suffused with brown distally and with green proximally.

*Head width:*  $1.64 \pm 0.09$  mm (25 larvae).

*Duration of stadium:*  $3.5 \pm 0.7$  days (46 larvae).

**Fifth-Stadium Larva** (Figs. 3, 4). Head flesh-coloured, inconspicuously mottled with pale fawn. Arcs free of mottling diverging upward and outward from centre of face. Prothoracic shield pale cream or white, mottled with pale greenish-grey; a median and a pair of submarginal lines free of mottling. Suranal shield pale greyish-green, mottled with white or pale cream. Maculation of trunk highly unusual, and with normal zonation of dorsum difficult or impossible to distinguish. Dorsum creamy-white with a confusing array of circles, bars, and undulating lines of greyish-green. Spiracular band creamy-white. Suprapodal area greyish-green mottled with cream. Mid-ventral area paler green than suprapodal area. Spiracles with light-brown rims. Thoracic legs cream, weakly suffused with green.

*Head width:*  $2.52 \pm 0.08$  mm (11 larvae).

*Duration of stadium:*  $4.9 \pm 0.8$  days (46 larvae).

**Pupa** (Figs. 4, 6, 7). Uniform mahogany brown. Spiracles on abdominal segments 5, 6 and 7 borne in shallow oval pits; spiracular sclerites moderately projecting. Anterior marginal areas of abdominal segments 5, 6 and 7, with a narrow band of fine but rather conspicuous pitting. Proboscis terminating well anterior to apexes of wings. Cremaster consisting of an elongate conical prolongation of the tenth abdominal segment bearing apically four elongate slender setae.

*Length from anterior end to posterior margin of fourth abdominal segment:*  $9.2 \pm 0.3$  mm (14 pupae).

#### ACKNOWLEDGMENTS

I am grateful to Mr. John E. H. Martin of this Institute for assistance in the field and for the photographs accompanying this paper. I appreciate the help of my associate, Mr. Eric Rockburne, who measured the immature stages and drew the cremaster area of the pupa.

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#### LIFE HISTORY NOTES ON *CALLOSAMIA SECURIFERA* (SATURNIIDAE)

On 29 August 1970, three 2nd instar larvae and nine eggshells of *Callosamia securifera* (Massen) were found on a low shrubby example of its foodplant, *Magnolia virginiana* L. (Sweet Bay). The larvae were found approximately eight miles north of McClellanville, Charleston County, South Carolina. The area is typical of coastal South Carolina, with many of the swampy pine forests where *M. virginiana* is common. The





*Callosamia carolina*, Jones  
- leg. M. Van Buskirk

Fig. 1. *Callosamia securifera* (Massen): A, ova shells; B, 5th instar larva; C, cocoon; D, adult male.

McClellanville area is of special interest, as it is one of the few areas in the U.S. where all three species of *Callosamia* fly sympatrically: *C. angulifera* Walker in association with *Liriodendron tulipifera* L. (Tulip Tree), *C. promethea* Drury in association with *Symplocos tinctoria* L'Hérit (Horse Sugar), and *C. securifera* in association with *M. virginiana*.

The three larvae were found singly on the undersides of the leaves, resting on the midrib. The eggshells were all on the underside of one leaf, located near the tip in a small cluster. Perhaps the ova are usually deposited in this manner, but this is only conjecture, as no other eggs have been found. Even after stripping the shrub to the ground, there was no trace of the other six larvae. Evidently the attrition rate to parasites and predators is quite high. Interestingly, these three larvae seemed to have lost the usual gregarious tendencies so prevalent with early instar *Callosamia* larvae, as they were all found some distance apart on the plant. The larvae from previous laboratory-reared broods of the three *Callosamia* species invariably remained gregarious until third instar.

According to all known records, this is the first instance of *C. securifera* larvae being found in the natural state, although the cocoons are often found in the McClellanville area during the winter months. Since F. M. Jones's original description of the adults and larvae (1909, Entomol. News 20: 49-52), little has been published on *C. securifera*. It is now known to be a distinct species and not a subspecies of *C. angulifera* as believed previously. The totally different foodplant, sympatric flight with *C. angulifera*, distinctive reproductive habits, and unique cocoon leave no doubt that *C. securifera* is indeed a valid species.

The larvae were reared outdoors on caged examples of *M. virginiana*, but unfortunately only one of the three was reared through to an adult. One larva escaped, while a second fell prey to a stinkbug in late 5th instar. (However it was vacuum-freeze dried and preserved for the accompanying figure.) Due to normal limits of variation, the larvae are impossible to distinguish from those of *C. angulifera*. Hopefully more careful observation of these two species in the larval stages will yield some distinguishing characters. The single remaining larva spun a cocoon in early October of 1970.

The cocoon is perhaps the most distinctive aspect of the life history of *C. securifera*. The always large, baggy, pendant cocoon is wrapped in several leaves and attached securely to a twig of the foodplant. When freshly spun the cocoon is of a beautiful silvery tan but fades somewhat with weathering. The cocoon from the last remaining larva, an excellent example, is shown on the accompanying figures. While the length of the cocoon's peduncle varies, as does the irregular shape, it never resembles the conical, compact cocoon of *C. promethea* or the loosely woven dark brown cocoon of *C. angulifera*.

A male emerged from the cocoon on 22 March 1971, shortly after sunrise. The premature emergence (4-6 weeks early) of the adult was puzzling, since it was reared under natural conditions and left outdoors throughout the winter until it emerged. The normal flight period for the first brood of *C. securifera* is from late April into early May, depending on weather conditions. There is a second brood in early to mid-August. These late summer adults of *C. securifera*, like those of summer brood *C. angulifera*, are much darker than the spring adults.

More careful notes were not taken on the life history of these first wild larvae, in anticipation of another, more detailed paper on this species by Dr. Richard B. Dominick and Mr. Charles R. Edwards of the Charleston Museum, Charleston, South Carolina. These men have spent the better part of two years thoroughly studying the habits and life history of *C. securifera*. Their paper, now in preparation, will have a wealth of previously unknown facts concerning the life history and ecology of this rare and beautiful silk moth. I extend my sincere thanks to these close friends who ~~had~~ took time out from an unbelievably busy schedule to photograph the figures in this article.

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THE LIFE HISTORY OF *SCHINIA JAEGERI* (NOCTUIDAE)

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*Schinia jaegeri* (Sperry, 1940) feeds in the larval stage in the heads of Orcutt's Aster, *Machaeranthera orcuttii* (Vasey & Rose) and of the Mecca Aster, *M. cognata* (Hall). Both asters are endemic to the Colorado Desert of southern California and to areas of northern Baja California (Munz, 1963). The distribution of *jaegeri* is probably coincident with the distribution of its two food plants.

Northward of the Colorado Desert *jaegeri* is replaced by the closely related *Schinia ligeae* (Smith) which feeds in the larval stage on the Mojave Aster, *Machaeranthera tortifolia* (Gray) (see Hardwick, 1971). The two species of moths are obviously closely related: their patterns of development are much the same, the adults are structurally very similar, and the pupae are essentially indistinguishable.

In areas of the Colorado Desert where its food plants are abundant and in early blossom, adults of *jaegeri* may usually be found without great difficulty. The species is in flight from the last week of March to the end of April.

## Behaviour

*Schinia jaegeri* is active only at night. During the daylight hours, the adults may be found resting either on the buds and blossoms or among the foliage of the two species of *Machaeranthera* on which the larva feeds. The eggs are laid either on the exterior of the unopened bracts of these, or between the florets of the open blossom. Occasionally eggs are deposited within the throats of individual florets. In Split Mountain Canyon, San Diego Co., a number of eggs deposited in exposed positions on the outside of the buds of Orcutt's Aster were found to be parasitized by a species of *Trichogramma*.

Of the few females confined in captivity, the maximum number of eggs deposited by any individual was 19.

The majority of eggs hatch on the seventh day after deposition. Larvae hatching from eggs deposited within the head immediately attack the florets. Larvae hatching from eggs deposited on the unopened bud generally enter the bud at its extreme apex. Occasionally a larva works its way downward under the bracts and attacks the bud at its very base by boring into the fleshy tissues of the receptacle. The survival rate among such receptacle-boring larvae is probably not very high. Among a large

number of aster buds that were dissected, very few penetrations through the receptacle to the seed layer were noted.

Larvae generally remain within the initial head until they have reached one of the median stadia. Usually during the fourth stadium, the larva quits the first head and enters a second which it bores into from the top. Feeding is usually completed within the second head.

Forty-six of 52 individually reared larvae matured in five larvae stadia, the remainder in four.

The ultimate-stadium larva assumes a decided reddish tone on the dorsum a day or so before it enters the earth to form its pupal cell. The majority of the year is spent as a pupa a few inches below the surface of the soil.

### Description of Stages

The following descriptions of immature stages are based on the progeny of three females taken at Biskra Palms, near Indio, California, and on eggs dissected from the Mecca Aster in Painted Canyon, Mecca, Calif., and from Orcutt's Aster in Split Mountain Canyon, San Diego Co., California. Rearing techniques employed were those outlined by Hardwick (1958). The estimate of variation following the mean for various values is the standard deviation.

**Adult** (Figs. 1, 2). Head, thorax and abdomen clothed with cream vestiture. Forewing cream, vaguely marked with white and occasionally shaded with pallid fawn. Transverse anterior line rarely defined, white when present, strongly angular outwardly, the apex of the angle resting on the cubitus stem. Basal space uniform cream. Transverse posterior line rarely defined, white, excurved around cell, then angling inward to trailing margin. Median space narrow, occasionally suffused with pallid fawn; orbicular spot not defined, reniform spot occasionally evident as a narrow, whitish, arc. Subterminal space occasionally suffused with pallid fawn. Fringe and terminal space concolorous with basal space. *Hind wing* usually cream, occasionally pallid fawn; fringe cream. *Underside* of both wings shining cream.

*Expanse*:  $29.7 \pm 2.4$  mm (58 specimens).

**Egg** (Fig. 3). Pale cream when deposited and remaining unchanged during the next day. Egg assuming a slight pinkish tone on second day; then darkening to a light orange during third and fourth days. Anterior half of egg gradually becoming darker in colour than posterior half; during the fifth and sixth days, anterior half reddish-brown and posterior half light greyish-orange. Egg turning grey on day of hatching, and head capsule becoming visible through chorion a few hours before hatching.

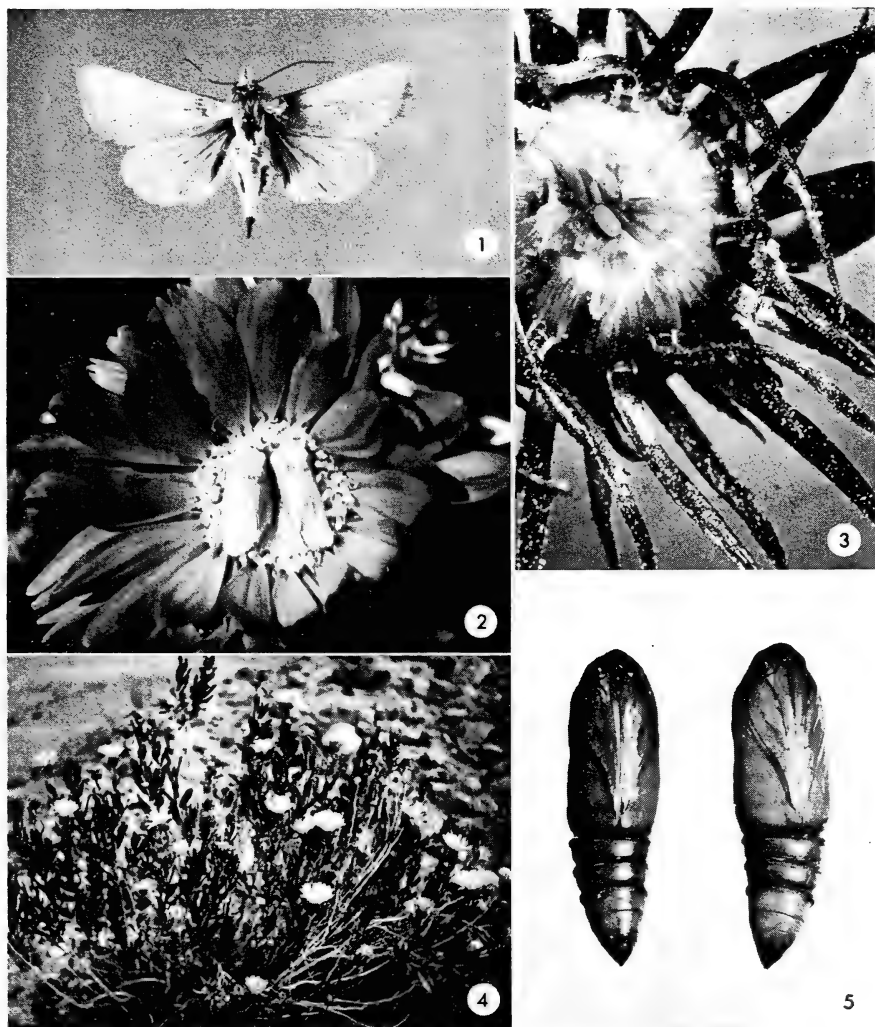
*Dimensions of egg*: length,  $1.66 \pm 0.07$  mm; diameter,  $0.84 \pm 0.04$  mm (26 eggs).

*Incubation period*:  $7.2 \pm 0.6$  days (27 eggs).

**First-Stadium Larva**. Head medium orange-brown to blackish-brown. Prothoracic and suranal shields dark smoky-brown. Trunk usually a translucent purplish-brown when larva hatches, becoming light yellow or cream after feeding. Spiracles with medium- to light-brown rims. Thoracic legs smoky-brown.

*Head width*:  $0.477 \pm 0.016$  mm (23 larvae).

*Duration of stadium*: larvae maturing in 5 stadia,  $4.7 \pm 1.4$  days (46 larvae); larvae maturing in 4 stadia,  $5.3 \pm 0.6$  days (6 larvae).

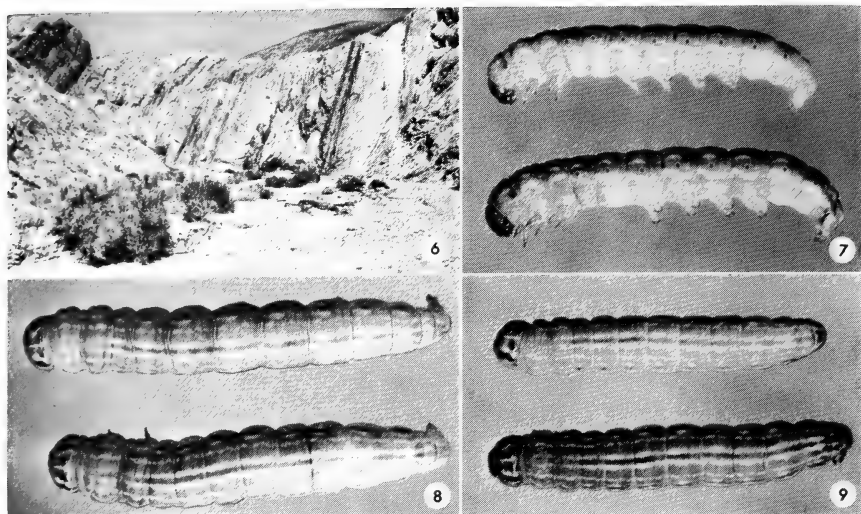


Figs. 1-5. *Schinia jaegeri* (Sperry) and its food plants. 1, Adult, Split Mountain Canyon, San Diego Co., Calif.; 2, a pair of adults, presumably freshly broken from copula, on head of Mecca Aster; 3, egg on bud of Mecca Aster; 4, Orcutt's Aster; 5, ventral aspect of pupae.

**Second-Stadium Larva.** Head orange-brown, variably mottled and reticulated with slightly darker brown, but usually inconspicuously so. Prothoracic shield medium chocolate-brown to dark smoky-brown, usually with a light median line. Suranal shield smoky-fawn to dark smoky-brown. Trunk cream or greyish-cream. Spiracles with light- to medium-brown rims. Thoracic legs smoky-brown.

*Head width:*  $0.76 \pm 0.04$  mm (19 larvae).

*Duration of stadium:* larvae maturing in 5 stadia,  $2.5 \pm 0.7$  days (46 larvae); larvae maturing in 4 stadia,  $3.3 \pm 0.9$  days (6 larvae).

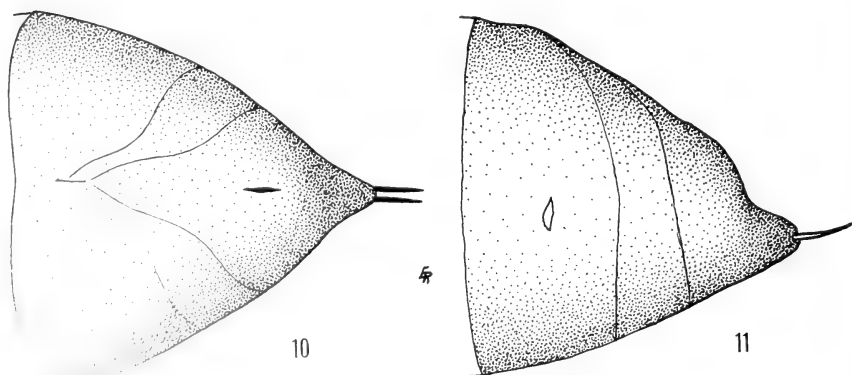


Figs. 6-9. *Schinia jaegeri* (Sperry) and its habitat. 6, Painted Canyon, Mecca, Calif., with clumps of the Mecca Aster; 7-9, right lateral and dorsal aspects of ultimate-stadium larvae.

**Antepenultimate-Third-Stadium Larva.** Head orange-brown, with darker-brown reticulation and shading dorsally. Prothoracic shield smoky-fawn, marked with blackish-brown and with a median and a pair of submarginal, cream lines. Suranal shield smoky-brown, often with three, cream or fawn, longitudinal lines. Trunk cream or greyish-cream, usually with 2 pairs of pale lines on dorsum. Spiracles with dark-brown or black rims. Thoracic legs smoky-fawn to medium smoky-brown.

*Head width:*  $1.10 \pm 0.05$  mm (33 larvae).

*Duration of stadium:*  $2.4 \pm 0.6$  days (46 larvae).



*Schinia jaegeri* (Sperry), apical abdominal segments of pupa. 10, lateral. 11, dorsal.

**Penultimate-Stadium Larva.** Head orange, shaded and reticulated with medium brown. Prothoracic shield very dark brown or black, with a white or cream median line and usually with a similar submarginal line on either side. Suranal shield dark smoky-brown with three longitudinal lines of white or cream, the median line often evanescent. Mid-dorsal band light grey or creamy-grey. Subdorsal area paler than mid-dorsal band, margined on either side by a pale-yellow line. Supraspiracular area and spiracular band concolorous with subdorsal area, separated from each other by a pale-yellow line. Ventral region pallid grey. Spiracles with black rims. Thoracic legs smoky-fawn.

**Head width:** fourth-stadium larvae maturing in five stadia,  $1.60 \pm 0.06$  mm (37 larvae); third-stadium larvae maturing in four stadia,  $1.32 \pm 0.06$  mm (6 larvae).

**Duration of stadium:** fourth stadium of larvae maturing in five stadia,  $2.6 \pm 0.3$  days (46 larvae); third stadium of larvae maturing in four stadia,  $3.7 \pm 0.9$  days (6 larvae).

**Ultimate-Stadium Larva (Fig. 7-9).** Head orange, often with a pair of dark-brown arcs on vertex. Prothoracic shield light brown, marked with black, and with three longitudinal bands of white or cream. Suranal shield medium to dark smoky-brown, with a cream submarginal line on either side and with at least a partial cream median line. Mid-dorsal band medium slate-grey, margined by pale-yellow bands. Subdorsal area paler grey than mid-dorsal band. Supraspiracular area somewhat paler than subdorsal area, margined on either side by a pale-yellow line; ventral marginal line usually broken. Spiracular band concolorous with subdorsal area, shaded in middle of each segment with pale creamy-grey, and margined ventrally by an irregular pale band. Suprapodal and mid-ventral areas light grey. Spiracles with black rims. Thoracic legs cream, tinged with orange.

**Head width:**  $2.23 \pm 0.13$  mm (20 larvae).

**Duration of stadium:** fifth stadium of larvae maturing in five stadia,  $9.6 \pm 1.8$  days (46 larvae); fourth stadium of larvae maturing in four stadia,  $9.0 \pm 1.4$  days (6 larvae).

**Pupa (Figs. 5, 10, 11).** Essentially indistinguishable from that of *Schinia ligeae* (Smith) (see Hardwick, 1971). Anterior marginal areas of abdominal segments often forming a more prominent ridge than in *ligeae*. Lateral cremaster setae present in some pupae of *ligeae*, absent from all pupae of *jaegeri* examined.

**Length from anterior end to posterior margin of fourth abdominal segment:**  $9.1 \pm 0.5$  mm (25 pupae).

#### ACKNOWLEDGMENTS

I am grateful to Mr. John E. H. Martin of the Entomology Research Institute for the fine photographs accompanying this paper, and to my associate, Mr. Eric Rockburne, for measuring larval structures and drawing the cremaster area of the pupa.

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## STUDIES ON THE *CATOCALA* (NOCTUIDAE) OF SOUTHERN NEW ENGLAND. III. MATING RESULTS WITH *C. RELICTA* WALKER

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Successful matings of *Catocala* moths have apparently been rarely achieved in captivity. I am aware of no published accounts of such matings in the North American literature. Considering, however, the many genetic, ecological, and evolutionary questions posed by this vast assemblage of moths, successful matings should provide results of wide interest. Consequently, I have begun attempts to mate *Catocala*, and this paper reports initial successes with *C. relictata* Walker.

*C. relictata* was selected for initial study, as its close European ally, *C. fraxini* Linnaeus, has been mated in captivity (e.g. Cockayne et al., 1937-38), and further, *C. fraxini* and *C. relictata* have been successfully hybridized (Meyer, 1952).

The present report is based on studies conducted from 1969-1971 in Leverett, Massachusetts. During that period a total of 541 adult *C. relictata* were reared from eggs, and 25 matings were observed.

### METHODS AND MATERIALS

*C. relictata* occurs in three forms in the northeast (Beutenmüller, 1903; Forbes, 1954): **typical**, with clouding of black scales between am. line and base of forewing, and between pm. and st. lines (Fig. 1a, e, f); **clara**, with these areas largely white (Fig. 1c, d); and **phrynia**, with a nearly even dusting of black scales over the entire forewing (Fig. 1b). The present mating studies involved only **typical** and **clara** moths, although wild-caught specimens from Leverett have been approximately 30% **typical**, 60% **clara**, and 10% **phrynia** (1968-71, 43 records).

### Rearing Procedures

The larval stages and pupa of *C. relictata* have been previously described in detail by Clark (1888) and Rowley & Berry (1910).

In the present study, eggs were obtained by placing wild-caught or mated adult females into paper bags which were hung outdoors for several days. The eggs were then transferred on small pieces of paper into glass food jars which were left outdoors to overwinter. Larvae hatched in May (initial hatch from 8-18 May over the three years) and were



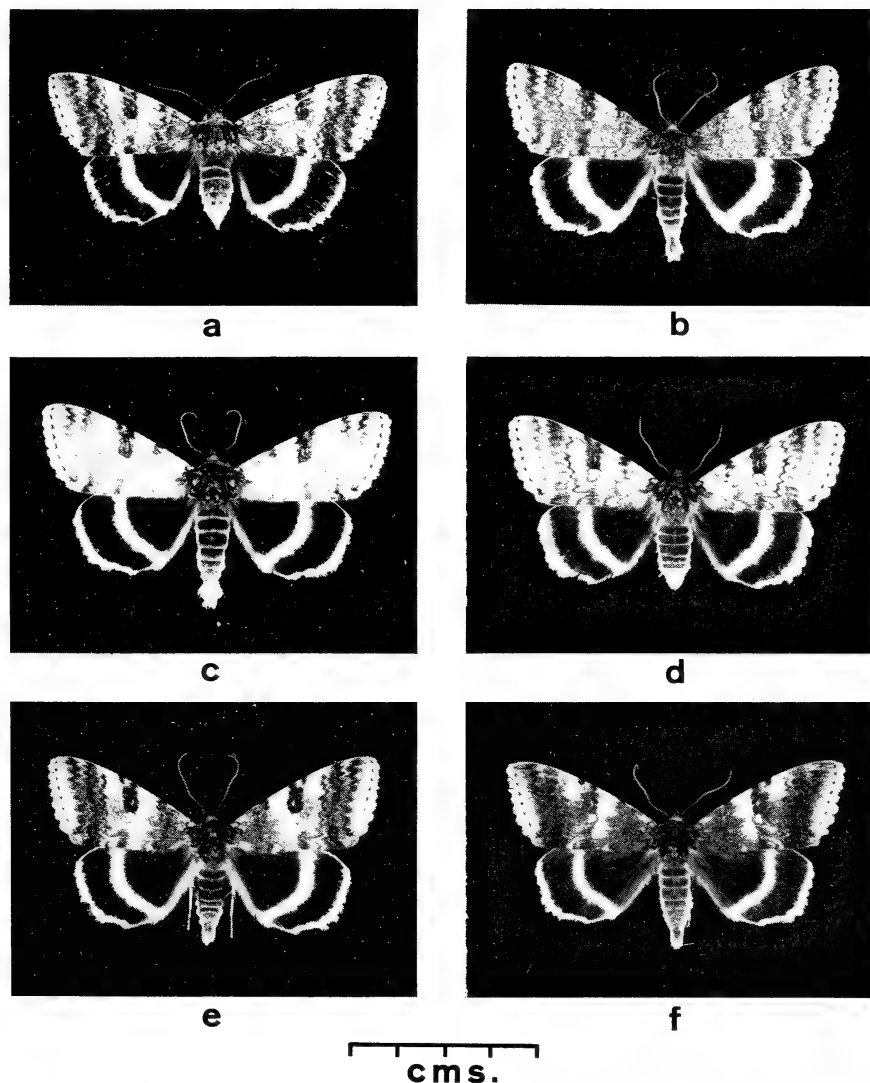


Fig. 1. Specimens of *C. relictta*: a.  $P_1$  wild-caught typical female; b. wild-caught phrynia male; c, d. lightest and darkest clara obtained in  $F_1$  crosses; e, f. lightest and darkest typical obtained in  $F_1$  crosses.

immediately supplied with fresh poplar leaves (*Populus tremuloides*). At 1-2 weeks of age the larvae were transferred individually into pint, plastic ice-cream containers. Herein each larva was provided with a poplar twig for resting and a dry, curled beech leaf (*Fagus grandifolia*)

TABLE 1. Mating success with *C. relictta*, 1969-70.

Situation	No. Paired	No. Mated	Percent Mated
LOCATION			
Indoors	21	20	95%
Outdoors	5	4	80%
CAGE			
Small	6	5	83%
Large	10	10	100%
Cylinder	10	9	90%

for pupating. Fresh poplar leaves were added, and frass removed, each day until pupation. Pupae were usually formed in the beech leaves and occasionally in the fresh poplar foliage (initial pupation from 15-22 June). Adults generally eclosed about one month later (initial eclosion from 15-18 July).

*C. relictta* did particularly well under these rearing conditions, with 80-90% survival from egg to adult being commonly obtained.

### Mating Procedures

The plastic containers housing the individual pupae were checked each day for adults. When a male and female were available for pairing, they were transferred from these containers into one of three different types of cages: *small*, homemade of aluminum window screening on a wooden frame (approx. 20 × 23 × 23 cm.); *large*, obtained from Ward's Natural Science Est. (14W 7500), made of nylon mesh on a plywood frame (approx. 28 × 25 × 41 cm.); *cylinder*, homemade from aluminum window screening, rolled into a cylinder (18 cm. diam. × 38 cm. high) and covered at both ends with cardboard pie plates. These cages were then either placed outdoors (on stumps, and hung from limbs) or indoors (basement, approx. 18°C., with small windows allowing some natural light). All paired moths were provided with an opportunity to feed from small pieces of sponge which were soaked daily with a honey and water solution.

The cages were checked by flashlight (covered with a sheet of red cellophane) at intervals during the night. At these times the behaviors of all moths were carefully noted, but prolonged observations of courtship were not attempted, as the flashlight seemed to distract and disturb the moths to some extent.

Mating was considered achieved only when a pair was observed in

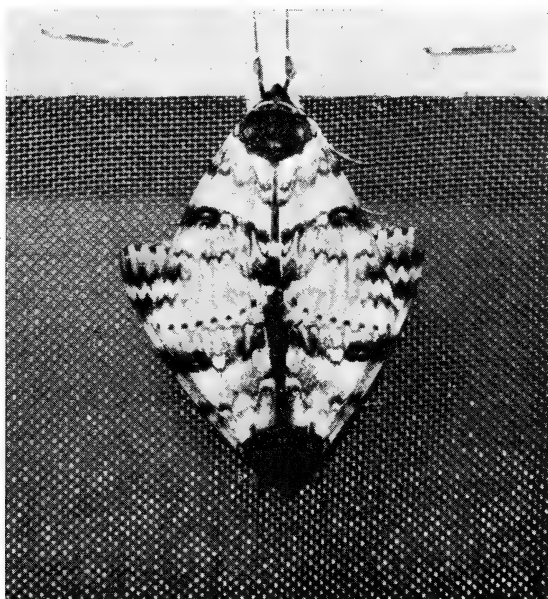


Fig. 2. *C. relictus* pair in copulation on side of large cage—female above, male below (approximately natural size).

actual copulation. On the day following this observation the female was bagged for eggs and the male killed and retained as a specimen. When the female died she was also retained—male, female, and eggs being labeled with a common symbol.

## RESULTS AND DISCUSSION

### Behavior

Of 26 pairs of moths which were carefully observed during the summers of 1969 and 1970, 24 (92%) were observed in copulation, and 20 of these matings resulted in fertile eggs (i.e. produced larvae). Mating success was high in all three types of cages, and both outdoors and indoors (Table 1).

Courtship behavior, though not observed in detail, seemed generally similar to that described for other noctuids (e.g. Shorey, Andres & Hale, 1962; Birch, 1970). The females almost invariably adopted a "calling" posture shortly after dusk, and maintained this posture (unless mating occurred) for most of the night. In this calling posture a female elevated the abdomen (from either a horizontal or vertical surface) above the plane of her partially spread wings (the wings being vibrated rapidly

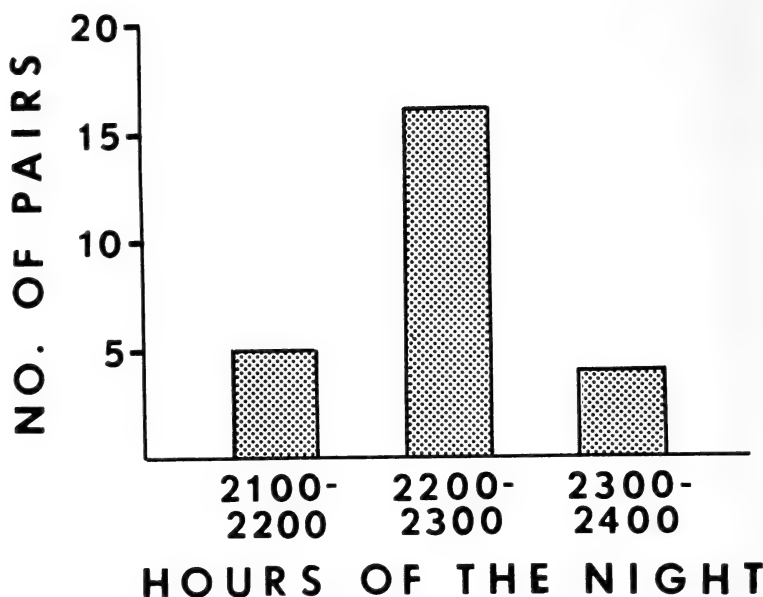


Fig. 3. Time of mating (Eastern Daylight Savings Time) for 25 pairs of *C. relictta* observed during the summers of 1969-71.

during high intensity calling), and protruded the pheromone-producing gland beyond the tip of her abdomen. Just prior to mating, considerable male activity (walking and flying about the cage) was noted, presumably involving behaviors similar to those described by Birch (1970). Copulation then quickly ensued, usually on the side of a cage (on three occasions under the roof), with the female the uppermost moth. After initial contact the hindwings of both moths were visible beneath their partially spread forewings, but shortly thereafter the wings were closed as in the resting posture, with the female's forewings overlapping those of the male (Fig. 2). Pairs remained in copulation for from 2-13 hrs., a longer period than that reported in other noctuids (Shorey et al., 1962; Birch, 1970).

Visual stimuli were apparently not required for courtship and mating, as successful copulations were achieved in essentially total darkness (basement). This agrees with prior observations on other noctuids (Shorey, 1964; Shorey & Gaston, 1970).

Although females were observed in the calling posture during all hours of the night, matings were initiated during a relatively short period (Fig. 3). These observations suggest that males were chiefly responsible for the timing of mating; and although daily cycles in male responsiveness

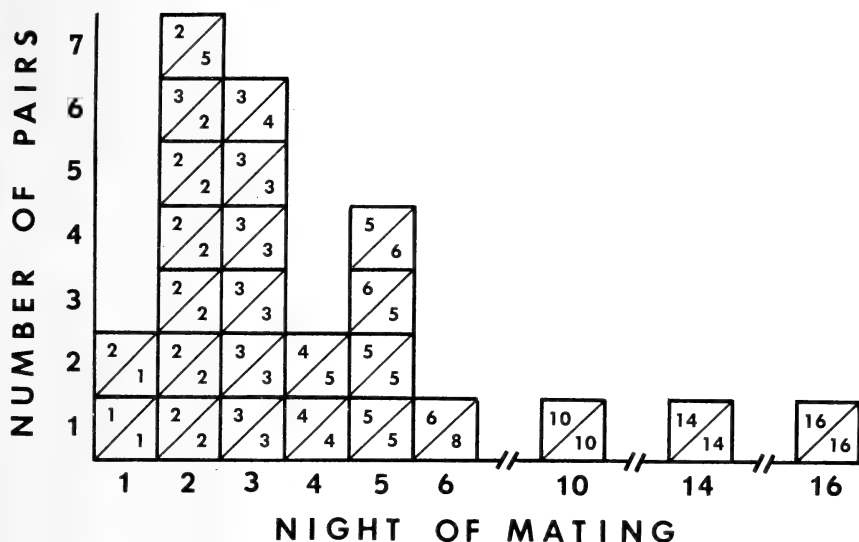


Fig. 4. Night following pairing during which mating occurred in 25 pairs of *C. relictta*. Actual ages of the moths from night of eclosion are given within each box (male/female).

to female pheromone are known in noctuids (Shorey & Gaston, 1964, 1965), the timing of mating is chiefly controlled in these species by a circadian rhythm of female pheromone release (Sower, Shorey & Gaston, 1970, 1971). The possibility then of chiefly male timing in *C. relictta* would seem to warrant further investigation.

The night during which mating occurred following pairing of the moths varied widely, and fertile eggs were obtained from matings involving males and females ranging from 1–16 days of age (Fig. 4). Some variability in the occurrence of mating was expected in view of prior studies on reproductive age in noctuids (Shorey, McFarland & Gaston, 1968; Shorey, Morin & Gaston, 1968), but I am not aware of prior reports of delays in mating extending to two weeks or more in caged moths which are apparently capable of mating much earlier.

A totally unexpected result obtained in this study was the failure of calling females to attract males to their cages. This occurred even though *C. relictta* were being captured in the study area at bait and in light traps, and despite the release of scores of unmated (marked) males into the study area. While many factors are known to reduce the effectiveness of pheromone attraction (Saario, Shorey & Gaston, 1970; Sharma, Shorey & Gaston, 1971), none of these would seem to account for the present total failure. Variable numbers of caged females were observed calling

every night over one-month periods during the summers of 1969 and 1970, and these periods included considerable variation in environmental factors such as humidity, temperature, wind, and moonlight. In addition, the height of the cages was varied between 0 and 6 ft. above the ground, and on occasion fresh poplar foliage was added to the cages (in the event that the female pheromone *plus* a chemical from the foodplant was necessary to attract males—as reported for the saturniid, *Antheraea polyphemus* (Riddiford & Williams, 1967)).

One possible explanation for this situation would involve postulating a non-chemical communicating stimulus which attracts males from a distance and which caged females are incapable of producing. Such a stimulus could conceivably be auditory (perhaps produced in free flight), and be analagous to the visual stimuli known to initiate courtship behaviors in butterflies (e.g. Magnus, 1963; Brower, Brower & Cranston, 1964). A significant role of auditory stimuli in directing the approach of courting moths has recently been reported in *Achroia grisella* (Fabr.) (Pyrilidae) (Dahm et al., 1971). Perhaps the males caged with the females in the present study were in close enough proximity to bypass any long-distance communication and to proceed immediately with chemically mediated courtship stages. Whatever the explanation, this matter warrants close study in the future.

### Genetics

All *C. relict*a discussed in this report are descendents of a wild-caught female taken in Leverett in 1968 (Fig. 1a). This **typical** female produced 90 eggs, from which 85 progeny ( $F_1$ ) were reared: 42 **typical** (20 ♂♂, 22 ♀♀) and 43 **clara** (27 ♂♂, 16 ♀♀). This 1:1 phenotypic ratio suggested that a single Mendelian factor was responsible for the difference between the **typical** and **clara** forms, and that the cross had involved a homozygote  $\times$  heterozygote for that factor. This suggestion was confirmed through subsequent crosses of the  $F_1$ , the **typical** allele proving to be dominant (Table 2).

The alleles were given the symbols *C* (dominant) and *c* (recessive), with *CC* and *Cc* representing respectively homozygous and heterozygous **typical** individuals, and *cc* representing homozygous **clara** individuals. Homozygous and heterozygous **typicals** were not phenotypically distinguishable with certainty, there being considerable and rather continuous variation among the **typical** progeny of all *Cc*  $\times$  *Cc* crosses. However, the darkest **typicals** were obtained in these crosses (e.g. Fig. 1f), and these may have been homozygous individuals. The extent of variation among **typical** and **clara** moths in the progeny of all  $F_1$  crosses is illus-

TABLE 2. Summary of *C. relictus* crosses, 1969-71.

Matings	Progeny				Totals	
	clara		typical			
	Brood Number	Male	Female	Male	Female	clara
<b>clara × clara (<i>cc</i> × <i>cc</i>)</b>						
08-70	23	19	—	—	42	—
09-70	8	5	—	—	13	—
11-70	5	2	—	—	7	—
02-71	10	12	—	—	22	—
Totals					84	0
<b>clara × typical (<i>cc</i> × <i>Cc</i>)</b>						
01-69	27	16	20	22	43	42
01-70	8	7	4	7	15	11
03-70	8	6	6	8	14	14
05-70	9	11	10	7	20	17
06-70	5	8	4	9	13	13
07-70	9	7	6	6	16	12
01-71	5	5	8	6	10	14
04-71	6	10	9	6	16	15
Totals					147	138
<b>clara × typical (<i>cc</i> × <i>CC</i>)</b>						
03-71	—	—	39	51	0	90
<b>typical × typical (<i>Cc</i> × <i>Cc</i>)</b>						
02-70	4	2	12	12	6	24
04-70	6	2	6	12	8	18
10-70	5	6	13	2	11	15
Totals					25	57

trated in Fig. 1 (c, d and e, f)—no intermediates between the forms were obtained.

All  $F_1$  crosses produced phenotypic ratios which did not differ significantly from those expected in one-factor crosses involving autosomal alleles and complete dominance (chi-square goodness-of-fit tests). However, the totals in  $Cc \times Cc$  crosses actually fitted a 2:1 (typical:clara) ratio better than a 3:1 (chi-squares of 0.29 and 1.33 respectively), suggesting that the homozygous dominant genotype may have been lethal in some cases (perhaps in the presence of certain modifiers). Close examination of the data reveals a marked deficit of typical females in brood 10-70 (Table 2). The two typical females obtained in this brood were rather light, whereas five of the 13 typical males were extremely dark. It may be that lethality here is similar to that described in situ-

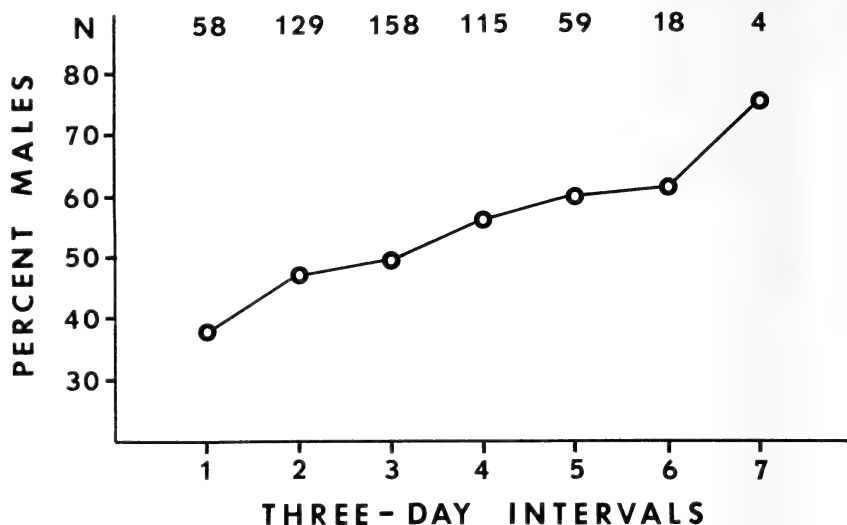


Fig. 5. Percentage of males eclosing over successive three-day intervals of the eclosion period for each brood (summed over 16 broods, 1969-71). The number of individuals eclosing is given above each point on the graph.

ations involving the sex-limited "alba" gene in *Colias* butterflies (Remington, 1954), but the present numbers are rather small, and further study is needed.

#### Sex Ratios

The over-all sex ratio in moths from 16 broods (Table 2) was 275 ♂♂ and 266 ♀♀, with only one brood (the previously noted 10-70) departing significantly from a 1:1 ratio (chi-square 3.84,  $P = 0.05$  in that case).

There was a consistent tendency for females to eclose before males (Fig. 5), with the sex ratio for eclosion days 1-10 summed for all broods being 188 ♂♂ and 211 ♀♀ (47% male), and for eclosion days 11-20 being 87 ♂♂ and 55 ♀♀ (61% male). These ratios are significantly different (chi-square,  $2 \times 2$  contingency test, 8.03;  $P < 0.01$ ).

In most Lepidoptera, males tend to eclose before females, and this certainly is true in *C. fraxini* (Cockayne et al., 1937-38). The significance of the present reversal of the usual trend is not yet apparent.

#### SUMMARY

Twenty-five matings were observed in caged pairs of *C. relictta* during the summers of 1969-71 in Leverett, Massachusetts. All of these matings



were initiated between 2100 and 2400 EDST, and it appeared that males were chiefly responsible for this timing. Successful matings were obtained with males and females ranging from 1–16 days of age. Progeny reared from these matings revealed that the expression of the **typical** and **clara** forms in the adults is largely controlled by a single gene, with the allele for the **typical** pattern being dominant. The possibility of some lethality among homozygous **typical** individuals was suggested. Over-all sex ratios were close to 1:1, but females tended to eclose before males.

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#### OBSERVED MATING BETWEEN *PIERIS RAPAE* AND *PIERIS PROTODICE* (PIERIDAE)

Late in the afternoon of 5 July 1971, I explored a weed-infested lemon and avocado orchard in Goleta Valley (Santa Barbara County, California), looking for *Nathalis iole* (Boisduval). *N. iole* had once been locally common in lemon groves in rural areas around Santa Barbara, but apparently had not colonized this orchard. The only butterflies sighted that afternoon were *Danaus plexippus* (Linnaeus), *Vanessa carye* (Hubner), *Pieris rapae* (Linnaeus) and *Pieris protodice* (Boisduval & LeConte). The latter two species were flying around the wild mustard in great abundance, fluttering close to the ground, and often landing—obviously getting ready to settle down for the night.

At approximately 1700 I noticed a copulating pair of *Pieris* land a few feet in front of me. Upon closer observation, I noticed that they were two different species, a male *P. rapae* and a female *P. protodice*. The female *protodice* was the flying partner. They were netted, pinched and carefully placed in an envelope. Still in copulation, I later mounted them on a piece of cardboard and placed them in my collection.

When two close species are found together in abundance, such interspecific matings are possibly not as rare as one might suspect. I have previously observed mating between these two species in the Santa Barbara area. About a decade ago, in a field across from Arroyo Burro Beach State Park, I noted a pair in copulation. Considering that these species are very common throughout the United States, and are usually ignored by local lepidopterists, many such matings could go unnoticed.

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SPECIES DIVERSITY IN *CATOCALA* (NOCTUIDAE) IN  
THREE LOCALITIES IN NORTH AMERICA

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Moths of the genus *Catocala* (Noctuidae) are abundant in deciduous woodland in many parts of North America, and in some localities between 30 and 40 species may occur together. The larvae of almost all the species of *Catocala* feed on the leaves of trees, especially trees belonging to the Salicaceae, Juglandaceae, Fagaceae, and Rosaceae. Each species of moth tends to be confined to a rather small range of tree species. Many species of *Catocala* are extremely similar, but there appears to be no evidence of natural hybrids (Sargent & Hessel, 1970). The most obvious difference between species is the color and pattern of the hindwing which, at least during daylight, is only apparent when a moth is startled from its resting place on a tree trunk. It would seem likely that the diversity in the pattern of the hindwing is in some way related to the predatory behaviour of birds, although exactly how this is achieved is not known (Sargent, 1969).

Sargent & Hessel (1970) have published information showing the relative abundance of species of *Catocala* at two localities in the United States. In 1961 I obtained a rather similar sample from a single locality in Michigan, and my aim in this paper is to compare the diversity of species in the three samples. But before discussing the estimates of diversity it is necessary to outline briefly the different methods used to obtain the three samples:

Sample 1 consists of 2009 moths obtained at several localities in Franklin and Hampshire Counties in north-central Massachusetts. Specimens taken at bait (a mixture of brown sugar and beer painted on tree trunks) comprise 84% of the sample, while 12% were taken at light, and the remaining 4% were found resting on tree trunks. The specimens were obtained in the summers of 1964–69, baited and light-trapped specimens being obtained mostly before midnight. Very few specimens were collected after early September, a month in which many species of *Catocala* are common. Possibly some individuals were recorded more than once as most of the moths were released after being examined, although Sargent & Hessel (1970) are of the opinion, on the basis of recaptures of color-marked individuals, that recaptures were few.

Sample 2 consists of 5806 specimens from a single site in Litchfield County, west central Connecticut, about 65 miles south-west of Amherst,

TABLE 1. Estimates of species diversity in three samples of *Catocala*.

Sample	N	S	$\alpha$ and Standard Error
1. Franklin and Hampshire Counties, Mass.	2009	33	$5.61 \pm 0.40$
2. Litchfield County, Conn.	5806	39	$5.62 \pm 0.33$
3. Livingston County, Mich.	1331	30	$5.45 \pm 0.43$

Massachusetts. All specimens were taken at lights, mostly from a single mercury vapor trap operated from dusk to dawn in the summers of 1961-65, 1967, and 1969. Trapping continued through September, and there is again the possibility that a few individuals may have been recorded more than once.

Sample 3 consists of 1331 specimens taken at a mercury vapor light operated on the Edwin S. George Reserve, Livingston County, Michigan, during the summer of 1961. The light was operated on almost every suitable night throughout the season and all specimens captured were killed. The light was not normally operated after about 1 a.m.

All three samples are from areas of deciduous woodland mixed with farmland and abandoned farmland. The essential point about the three samples is that number 1 differs markedly from numbers 2 and 3 by the method used to obtain the moths. The three localities are geographically separate from one another, but in view of the distribution and abundance of *Catocala* in North America it is likely that in at least some of the species there is gene flow between the areas.

Numerical estimates of species diversity are possible when both the number of species and the number of individuals per species are known. In estimating species diversity in the three samples I have used the method proposed by Fisher, Corbet & Williams (1943), amplified in Williams (1964). The method involves the assumption, which can be tested, that the distribution underlying the number of species represented by different numbers of individuals is approximately a logarithmic series. The distribution is defined by two parameters:  $x$ , a property of sample size only, and  $\alpha$ , a property of the populations sampled, which can be regarded as a measure of diversity. The method of estimating  $\alpha$  and its standard error is given in Fisher, Corbet & Williams (1943), and rough estimates can be read from the nomogram given in Williams (1964). Observed values of  $N$ , the number of individuals, and  $S$ , the number of species, are required.

TABLE 2. The three commonest species of *Catocala* in three different localities.

Locality	Species	% of Total Sample
1	<i>ilia</i>	34
	<i>ultronia</i>	16
	<i>crataegi</i> *	5
2	<i>palaeogama</i>	15
	<i>residua</i>	15
	<i>habilis</i>	11
3	<i>amica</i>	31
	<i>epione</i>	12
	<i>concumbens</i>	6

\* This includes records of *Catocala blandula* and *Catocala mira*.

The results for each of the three samples are given in Table 1. The three computed values of  $\alpha$  are similar and the standard errors are small. There is no significant difference between them, and the result is thus in accordance with the view that species diversity within a group of organisms is an intrinsic property of the environment. The three samples differ in the way in which they were obtained (the difference being greatest between sample 1 and samples 2 and 3) but this does not appear to have affected the value of  $\alpha$ . Many of the species taken are common to all three samples, but the relative frequency of most of the species in each locality is quite different. All three samples are characterised by a small number of abundant species and many relatively rare species, but a rare species in one sample is sometimes among the commonest in another. Table 2 shows the three most abundant species in each of the three samples. With the possible exception of *Catocala crataegi*,<sup>1</sup> which was not positively identified in sample 3, each of the species shown in Table 2 occurred at all three localities, but in each case the three most abundant species are different in each of the three samples. These differences are presumably associated with local ecological conditions, possibly with the relative availability of larval foodplants in the three localities, but the important point is that in each locality only three species comprise 55%, 41%, and 49%, respectively, of the total samples. This is the familiar result obtained whenever a group of species is sampled. But despite the variations in abundance of the species in the three localities, almost identical values of species diversity are obtained. This suggests that species of *Catocala* are partitioned out by the local environment in such a way that a constant diversity is maintained. It would be of considerable interest to know exactly how this is achieved.

<sup>1</sup> *Catocala mira*, which was tentatively identified in sample 3, is easily confused with *Catocala crataegi*, and it is possible that what I have called *mira* is in reality *crataegi*.

## SUMMARY

Samples of moths of the genus *Catocala* from three localities in the United States have values of species diversity that are not significantly different. It is suggested that this result supports the view that diversity is an intrinsic property of the environment and that although the individual species differ in their relative abundance in different places, an essentially identical pattern of diversity occurs in three widely separated yet ecologically similar localities.

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McFARLAND MOTH COLLECTION DONATED TO THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

Noel McFarland has been one of the more prominent students of North American moths for many years. When he moved to Australia he donated his splendid collection of 8,420 specimens to the Natural History Museum of Los Angeles County.

By far the most significant portion of the collection is 3,315 beautifully preserved larvae, in alcohol, and the accompanying copious notes on foodplants, behavior, and larval descriptions. The larvae of many species, such as *Saturnia albofasciata*, are represented in few, if any, other collections.

In addition to the larvae, there are 5,105 adult moths, many of which bear distinctive labels to associate them with rearing notes and preserved larvae. Included are most of the 278 species of moths taken during extensive collecting in Los Angeles County that resulted in "The moths (Macroheterocera) of a chaparral plant association in the Santa Monica Mountains of Southern California," (1965, *J. Res. Lepid.* 4: 43-74). In addition, there are a number of specimens from Kansas, and numerous moths from the edge of the Mojave Desert adjacent to the San Gabriel Mountains.

Earlier, in 1963, McFarland donated to the Museum 860 specimens of moths from Benton County, Oregon. These represent a large portion of the 360 species that he collected during a 20-month study that was the basis of his unpublished 1963 Master of Science thesis at Oregon State University, "The Macroheterocera (Lepidoptera) of a Mixed Forest in Western Oregon."

These generous donations are a valuable addition to the Museum's extensive holdings of western Lepidoptera, while the larvae will form a strong nucleus for the collection of immatures.

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POLYMORPHISM IN *PAPILIO GLAUCUS* L. (PAPILIONIDAE):  
MAINTENANCE OF THE FEMALE ANCESTRAL FORM

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The *Papilio glaucus* L. female is dimorphic. One form is dark and resembles *P. (Battus) philenor* L.; the other resembles the yellow male. The inheritance of female color is controlled by a Y-linked gene (Clarke & Sheppard, 1962). Yellow mothers produce yellow daughters and dark mothers produce dark daughters. Consequently the two morphs are in direct competition with each other; and, heterozygote advantage cannot be the mechanism which maintains the dimorphism.

The dark form of *P. glaucus* is thought to belong to the mimetic assemblage which surrounds *P. philenor*. Other members are *P. troilus* L., *P. polyxenes* (Fabricius), *Limenitis arthemis astyanax* (Fabricius), and the females of *Speyeria diana* (Cramer). The main evidence that the dark form of *glaucus* mimics *P. philenor* is the correspondence between the occurrence and abundance of the two. In general (Brower & Brower, 1962) the proportion of mimics is highest in the middle Atlantic States where *philenor* is common. This proportion decreases in a southerly and northerly direction as *philenor* decreases.

One hypothesis for explaining the maintenance of the dimorphic female population in *P. glaucus* is that the males show a mating preference for the yellow females. Burns (1966) has tested this hypothesis by counting the number of spermatophores present in the bursa copulatrix of the two morphs. He obtained data from two samples of females collected during the summer of 1965; one in the vicinity of Mountain Lake Biological Station, Giles County, Virginia, and the other in Baltimore County, Maryland. In each sample the mean number of spermatophores per female was higher in the yellow morph than in the dark morph (Mt. Lake, yellow morph-2.08 spermatophores, dark morph-1.69 spermatophores; Baltimore County, yellow morph-1.88 spermatophores, dark morphs-1.54 spermatophores).

The present study was suggested by the relatively small difference between the mean number of spermatophores per female (Mt. Lake sample, 0.39; Baltimore sample, 0.34) found by Burns. It seemed that further information about the insemination frequency in *P. glaucus* would be of interest.

Two hundred *P. glaucus* females were collected during August and

TABLE 1. Observed frequency distribution, expected frequency distribution (numbers in parentheses), and mean number of spermatophores in wild-caught females of *Papilio glaucus*.

Morph	Specimens (No.)	Number of Spermatophores				Mean Number of Spermatophores/ Female
		0	1	2	3	
Mimic	128	2 (2.56)	65 (65.92)	51 (51.84)	10 (7.68)	1.54
Yellow	72	2 (1.44)	38 (37.08)	30 (29.16)	2 (4.32)	1.44
Total	200	4	103	81	12	1.51

September of 1966, 1967 and 1968 from two valleys in Albemarle County, Virginia; one in the Blue Ridge Mountains (elevation 800'), the other approximately 24 miles east of the Blue Ridge (elevation 590'). The butterflies were found in abandoned fields in which thistle was growing. Streams and larval foodplant (*Liriodendron* and *Prunus*) were located nearby.

The females were either dissected immediately after they were caught or were frozen alive in a moist chamber and dissected later.

A comparison of the mean number of spermatophores per female (Table 1) shows that the yellow females ( $\bar{x} = 1.44$ ) were inseminated less frequently than the mimic females ( $\bar{x} = 1.54$ ). However, this difference is not significant ( $\chi_{(2)}^2 = 2.07$ ;  $.50 > P > .30$ ; categories 0 and 1 spermatophores combined). Statistical analysis also shows that there was no heterogeneity with respect to locality ( $\chi_{(1)}^2 = .34$ ;  $.80 > P > .70$ ).

The results, then, show that there is no difference in the frequency of insemination between the mimetic and yellow females in the population studied. These results conflict with those of Burns (1966) and with some but not all of the data collected by Levine (1970) from females found in the vicinity of Mountain Lake, Virginia.

The reason for the discrepancy between the two sets of data is not clear. It may be related to the altitude at which the butterflies are found, the relative frequency of the model in relation to the frequency of *P. glaucus*, or the relative frequencies of the two female morphs. The ratio of dark to yellow morphs is 6:1 in the Mountain Lake area and 2:1 in Albemarle County, while the yellow butterflies are preferentially inseminated at Mountain Lake and are inseminated equally as frequently as the mimics in Albemarle County. Thus, it is also possible that, as in the case of *Drosophila pseudoobscura* (Ehrman, 1967; Spiess, 1968), female mating advantage occurs in *P. glaucus*. That is, that where the morph is rare



it is inseminated more frequently. This hypothesis can be tested by obtaining data on the relative frequency of insemination of mimic females in populations where the proportion of the mimics is small.

While the mechanism which maintains the dimorphism in *P. glaucus* is not yet clearly understood, the evidence collected to date shows that regional differences exist in the frequency with which the two female morphs are inseminated.

#### ACKNOWLEDGMENT

This research was done while working in the laboratory of Dr. J. J. Murray, Jr., in the Department of Biology, University of Virginia, Charlottesville, Virginia. My thanks to Dr. Murray for his encouragement and for the use of his laboratory facilities.

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#### PSEUDOPHILOTES BEURET, 1958

In a recent article of mine about *Glaucopsychie piasus* I called attention to the fact that *Philotes sonorensis*, the type species of Scudder's genus, is generically different from the rest of the genus found in North America. This requires a different name for *enoptes* and its allies. Such a name has been proposed. It is *Pseudophilotes* Beuret, 1958, with European *baton* as its type species. *Baton* is cogenetic with *enoptes*, et al.

The probable reasons for this generic name being overlooked by American taxonomists are two: the *Zoological Record* citation made no mention of nearctic members in *Pseudophilotes*; the paper in which the name was proposed is in a journal rarely seen in North America. The full citation for the description of *Pseudophilotes* is: Beuret, H., 1958, "Zur systematischen Stellung einiger wenig bekannter Glaucopsychidi (Lep., Lycaenidae)" *Mitt. ent. Ges. Basel (N.F.)* 8: 61-79, 1 pl., 12 figs.; 8: 81-100, 13 pls. The original description begins on page 100.

I wish to thank Dr. Lionel G. Higgins for calling this publication to my attention.

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JUNIPERUS (CUPRESSACEAE) SPECIATION AND THE  
RANGES AND EVOLUTION OF TWO CALLOPHRYS  
(LYCAENIDAE)

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It seems popularly assumed that the allopatric distributions of *Callophrys* (*Mitoura*) *siva* Edwards and *C. (M.) gryneus* Huebner are determined by the ranges of the several "species" of *Juniperus* which are the larval food-plants. Klots (1951) reports *C. (M.) gryneus* as feeding on *Juniperus virginiana* L. while Brown (1957, and in correspondence) reports *C. (M.) siva* utilizing several western junipers like *J. scopulorum* Sarg., *J. utahensis* Engelm., and *J. occidentalis* Hock. There is no other discussion in the literature known to this author which indicates opposing evidence to this popular assumption. Remington & Pease (1955) seem to sense the confusion within *Juniperus* taxonomy and report *C. (M.) gryneus* as feeding simply on "*Juniperus* sp." They also establish the usability of Swamp White Cedar [*Chamaecyparis thyoides* (L.)] for *C. (M.) gryneus*.

Until recently there has been no definitive work on the speciation of *Juniperus* in the areas of the United States including the distributions of *C. (M.) siva* and *C. (M.) gryneus*. Van Haverbeke (1968) has produced a detailed computer analysis of morphological and lipid characters (the latter analyzed by infrared spectroscopy) of *Juniperus* spp. in which he develops indices of hybridization between *J. scopulorum* and *J. virginiana* in the Missouri River Basin. The important problem is whether the bi-hybrid swarm of *Juniperus* he describes is best characterized as two species or simply variation within one clinal situation obscured through years of evolution. In his conclusions, through the analysis of statistical distributions, he presents several evaluations which strongly support the presence of two species (*J. scopulorum* and *J. virginiana*). Although no extreme parental types were discovered east or west in his study areas, he favors the conclusion that *J. virginiana* and *J. scopulorum* possess integrity enough to warrant his interpretation of data as percentage of each of these species' *germ plasm* in each study area. The data and conclusions within his study are important in making comments on factors determining the distribution of the two species of *Callophrys* considered in this paper.

In recent years *C. (M.) siva* has been reported on the Great Plains in a number of populations. Johnson (1972) reports *C. (M.) siva* in eight Nebraska counties, a few east of the 100th meridian. John S. Nordin (in

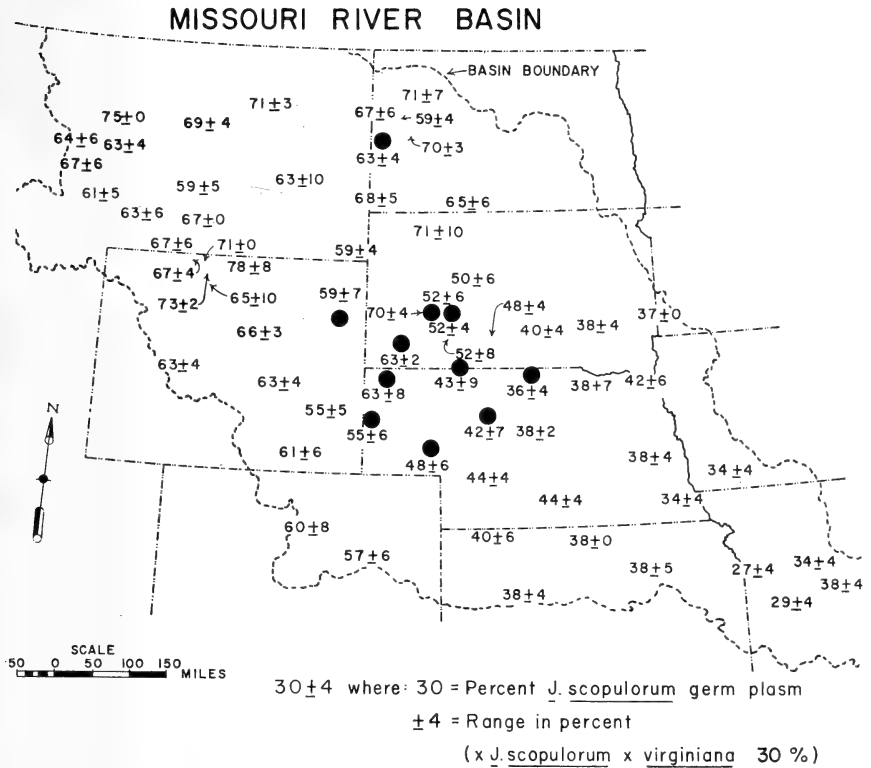


Fig. 1. Locations of known *Callophrys* (*Mitoura*) *siva* populations on the Great Plains superimposed above the plus-or-minus sign of a Van Haverbeke computation. Note that one population ( $70 \pm 4\%$ ) is located by an arrow and that the single Wyoming population corresponds to no Van Haverbeke computation. In the figure a computation such as  $30 \pm 4$  means 30% plus or minus 4% *J. scopulorum* "germ plasm."

Counties in which *C. (M.) siva* populations occur, with the general Van Haverbeke percentage given to facilitate more rapid association, are listed below. Two counties named together indicate juniper areas running across county boundaries; county locations of particular areas mentioned in the text are noted.

**North Dakota:** Billings County (63%); **South Dakota:** Pennington County (Black Hills area) (70%), Meade County (52%), Custer County (63%); **Wyoming:** Weston County (none); **Nebraska:** Dawes County (63%), Cherry County (43%), Brown and Rock Counties (Long Pine Recreation Area) (36%), Banner and Scotts Bluff Counties (55%), Thomas County (Nebraska National Forest at Halsey) (42%), Keith County (48%).

correspondence) reports the species at several locations in western and central South Dakota, and he and F. Martin Brown (in correspondence) report specimens from North Dakota. All of these populations occur (except for the Black Hills of South Dakota) in scattered escarpments or in areas of *Juniperus* on bluffs and buttes on the plains. The geographical locations of these populations can be seen in Fig. 1.

Fig. 1 superimposes the location of known populations of *C. (M.) siva* upon Van Haverbeke's figure of computer percentages of hybridization based on the sum of all his analyses of characters. The dots representing populations of *C. (M.) siva* are located directly above the plus-or-minus sign of the corresponding Van Haverbeke computation except where located by an arrow (see explanation of figure).

A great amount of variation in the type of juniper being utilized by *C. (M.) siva* is apparent, varying from  $70 \pm 4\%$  *J. scopulorum* in the Black Hills of South Dakota to  $36 \pm 4\%$  *J. scopulorum* in the Long Pine area of north-central Nebraska. Though this information is interesting, it gains its greatest import when compared to hybrid indices for *Juniperus* populations occurring into the range of *C. (M.) gryneus*. These indices are given elsewhere in Van Haverbeke's paper. Indices for *Juniperus* spp. in northeast and central Missouri, within the range of *C. (M.) gryneus* (the species is also reported in Nebraska by Klots, 1951, but was not validated by Johnson, 1972) range up to  $38 \pm 4\%$  *J. scopulorum*, and in areas of the eastern United States upwards to 39% *J. scopulorum*. The latter, however, requires caution due to the small amount of sampling in extreme eastern areas.

In the intervening area between the allopatric ranges of *C. (M.) siva* and *C. (M.) gryneus* there is considerable overlapping in the identity of the type of *Juniperus* available for food-plant use. The question emerges whether there is a threshold at which *C. (M.) siva* and *C. (M.) gryneus* segregate in their use of food-plants. Such segregation could be in reaction to morphological characters or chemistry. If segregation exists there must be some type of selection of juniper in the areas where the integrities of juniper used by the two species overlap. Such a selection might not be made by the female imago but might simply be due to larval mortality, or sterility of resulting adults, when ova are laid on unacceptable plants. However, it is equally possible that there may be no segregation due to food-plant type between these two butterfly species and that some other factor is keeping them allopatric in distribution. This indicates the possibility that the two species may eventually become sympatric.

The populations of *C. (M.) siva* in north-central Nebraska are newly discovered, and therefore their length of establishment is not known. However, the species was never reported in these areas in the early literature on Nebraska Rhopalocera. *C. (M.) siva* could have reached eastern outposts like the Nebraska National Forest at Halsey and the Long Pine Recreation Area in Nebraska by import of *Juniperus* seedlings planted in these areas by the Forest Service in fairly recent years. This opens the

possibility of germ plasm "pollution" of the *Juniperus* populations by the introduction of western imports.

There are two possibilities emerging from these data: the sympatry of *C. (M.) siva* and *C. (M.) gryneus* and its ramifications, or the segregation of the two (though the types of juniper available for utilization, according to Van Haverbeke's evaluation, seem to overlap). It would be desirable to experiment with the food-plant preferences of *C. (M.) siva* and *C. (M.) gryneus* in the laboratory. It is, however, the purpose of this paper to point out that the new evidence of *Juniperus* hybridization presented by Van Haverbeke has important bearing on lepidopterists' evaluation of the distribution of species of butterflies feeding on that taxon of plants. If *C. (M.) siva* and *C. (M.) gryneus* have evolved into two distinct species through isolation of their gene pools, it seems that some barrier to their sympatry must have been imposed at some time. If *J. scopulorum* and *J. virginiana* once had extreme parental type distribution areas, which are now introgressing spatially east and west, there might be some evidence of a former barrier. Within these two former distribution areas of *Juniperus* parental types might have been the harbors of the populations which evolved what we call *C. (M.) siva* and *C. (M.) gryneus*. Perhaps fluctuations in distributions and barriers in the history of *Juniperus* left the *Callophrys* ranges as "relicts" of former ranges of more typical juniper parental types. If, as Van Haverbeke suggests, *J. virginiana* might be an eastward evolutionary manifestation of *J. scopulorum*, there is a vague possibility that the original gene pool of *C. (M.) gryneus* utilized Swamp White Cedar and later adapted to *Juniperus* spp. as a food-plant.

Certainly the current taxonomic status of *Juniperus* species in the central United States has great import on the considerations of reasons for the respective distributions of *C. (M.) siva* and *C. (M.) gryneus*, and reminds lepidopterists to be more careful in forming generalizations about insect distributions because of their food-plants until more fully aware of the complexities in the plant groups themselves.

#### ACKNOWLEDGMENTS

Dr. John S. Nordin (Webster, South Dakota), Dr. F. Martin Brown (Colorado Springs, Colorado), and Mr. Glen Viehmeyer (North Platte Station, University of Nebraska) provided additional data for the study. Dr. John C. Downey (University of Northern Iowa, Cedar Falls) and Miss Doris Gates (Chadron State College, Chadron, Nebraska) made helpful suggestions concerning the project, and Mr. Leonard Running (Custer, South Dakota) accompanied the author on collecting trips. Dr.

David F. Van Haverbeke (University of Nebraska, Lincoln) generously allowed complete access to his *Juniperus* study including the reproduction of one figure.

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#### ACCIDENTAL OCCURRENCE OF *AGLAIS URTICAE* (NYMPHALIDAE) IN NOVA SCOTIA

On November 7 1970, John Godfrey of the faculty of Dalhousie University in Halifax, unpacked a crate of books shipped by sea from England. A butterfly flew out of the crate and was captured and brought alive in a plastic box to FWS by George Halverson, a neighbor of Mr. Godfrey's. The specimen, a fresh male of *Aglais urticae* (Linnaeus), could not be killed until the following day, by which time the wings were worn and chipped.

According to Mr. Godfrey the crate was packed and closed in Oxford, England on August 23 1970, and left England by sea in mid-October. The time elapsed between packing and unpacking was 76 days. Mr. Godfrey did not notice a pupal skin in the crate.

The interesting aspect of this occurrence is our knowledge of how the butterfly arrived in Nova Scotia. Had it escaped and then been collected outdoors in Halifax, its presence would have been quite baffling.

We know of no other North American records of this species. The specimen has been deposited in the Lepidoptera collection at the Nova Scotia Museum.

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#### BUTTERFLIES FEEDING ON A DEAD BOBCAT

On 6 July 1970, Mr. S. K. Dvorak and I captured the following butterflies, all males, imbibing the juices of a dead, decaying, young bobcat along a roadside: *Cercyonis oetus* (Boisduval) (1), *Speyeria zerene conchyliatus* (J. A. Comstock) (3), *Speyeria callippe* near *nevadensis* (Edwards) (1), and *Euphydryas chalcedona* (Doubleday), ssp. (1). The location was ca. 2 road mi. NE of SW entrance to Lava Beds National Monument (road from McCloud), Modoc National Forest, Siskiyou Co., Calif. Instances of butterflies at carrion are given by Payne & King (1969, J. Lepid. Soc. 23: 191-195).

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MALE GENITALIA OF LEPIDOPTERA: MORPHOLOGY AND  
NOMENCLATURE IV. NOTES ON TUXEN'S "TAXONOMIST'S  
GLOSSARY OF GENITALIA IN INSECTS": SECOND  
ENLARGED EDITION

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I have found that Parts II and III of this series (Okagaki et al., 1955; Ogata et al., 1957) are not referred to in the recently published Second Enlarged Edition of "Taxonomist's Glossary of Genitalia in Insects" edited by S. L. Tuxen (1970). I have also found that the nomenclature which we proposed in one of those papers was not included in the very extensive and useful Glossary but was nevertheless employed to define another term in the same Glossary. The situation is thus a source of further confusion. I therefore wish to rectify this point in the present paper. Also Alexander B. Klots (1970) in his text of Lepidoptera (p. 124) of this new edition commented on the nomenclature for the subdivision of the valva, and referred to Part I of this series (Sibatani et al., 1954). I have a different opinion on his points, and judge that a note on his text may be useful.

The Scaphium and "Sociuncus"

Ogata et al. (1957) proposed that the dorsal appendages belonging to the 10th abdominal segment of male Lepidoptera, which may be subdivided into the median *uncus* (sometimes divided medially) and lateral *socii* should be called collectively the *scaphium* according to the original terminology of Gosse (1882) in the absence of any other suitable name. We made this proposal because we considered the *socii* and *uncus* as two similarly weighted and not mutually exclusive derivatives of a morphological unit structure, and also because sometimes it is difficult to assign portions of this unit to either *uncus* or *socii*. The term *scaphium sensu* Ogata et al. has since been extensively used by Japanese authors (Shirôzu and Yamamoto, 1959; Shirôzu, 1960; Inoué and Kawazoé, 1964, 1965; Kawazoé and Wakabayashi, 1969), but it is not referred to in this sense in Tuxen's Glossary, let alone mentioned in the text. However, the Glossary lists on p. 295:

"Okonze (russian) ♂ Lep. Kusnezov 1924 (!) teste Shirôzu and Yamamoto 1956 in Lycaenidae. Lateral membranous area between tegumen and *scaphium*" (Italic and ! by A.S.).

Shirôzu and Yamamoto (1956) were using the nomenclature outlined by Ogata (1950) in a paper which briefly summarized the conclusion as

published later in this series, and in which the scaphium was defined in the sense of Ogata et al. (1957), and not of Pierce (1909) or of most other authors. The term *okonze* (to be spelled "okontse" according to the currently employed transliteration of Cyrillic) was also mentioned in that paper by Ogata (1950).

Since, however, Tuxen's book has fixed the meaning of scaphium in Pierce's sense (p. 326), the way to minimise the confusion is to drop the use of scaphium as proposed by Ogata et al. (1957), and I so advise those who have so far followed the latter. This does not, however, alleviate the need of a collective term for the morphological unit covering the uncus and socii, as the recent extensive use by Japanese authors of the term scaphium in this sense testifies. I therefore suggest a new term *sociuncus* to replace the scaphium in the sense of Ogata et al. (1957). This is a synthesis of the words socii and uncus, and I hope that it is self-explanatory. It may be argued that the need for such a term would be readily dissolved by an expression like "uncus-socii complex." However, contrary to what such an expression would seem to imply, the *sociuncus* is a structure of primary morphological significance, and the uncus and socii are its secondary derivatives and not *vice versa*. In this sense, the situation is not comparable with that of frequently used expressions like "harpe + ampulla region" (Shirôzu and Yamamoto, 1956) or "harpe-ampulla complex" (Inoué and Kawazoé, 1965) of the valva, because in the latter case, the harpe and ampulla are of primary significance, which may secondarily become united.

There are several other names proposed in Part III of this series which I think Tuxen's Glossary should have included, and therefore I attach a "Proposed Addenda" to it at the end of this paper. They include two unlisted names (*cochlear* and *fenestrula*) which have been extensively used by Japanese authors, as well as certain other terms which are now involved in confusion for which I am mainly responsible.

### Subdivision of the Valva

The second point I would like to discuss briefly concerns Klotz's statement (p. 124) in Tuxen's book:

"... these findings [recognition of "six" (actually seven) fundamental regions by Shibutani et al. (1954) in the valva—A.S.] do not agree in part with the very important conclusions of Forbes (1939) who studied the valval musculature, especially regarding the so-called "*clasper*," which in some groups has a separate musculature which would seem to infer a separate origin. Still more disparate are the conclusions of Birket-Smith (1965) about many structures, particularly of the valvae, based on studies of the structure and their musculature in Lithosiinae. This author introduces a completely new nomenclature, which deserves very careful consideration."



It is hard to understand the first half of this statement. The subdivision of the valva as proposed by Sibatani et al. (1954) was based on an extensive study of the musculature, and as far as the more specialised families of Lepidoptera are concerned, it supported the findings, if not the interpretation, of Forbes (1939). Especially difficult to follow is Klots's comment on the musculature of "clasper" (= *harpe*), because both in Forbes (1939) and Sibatani et al. (1954) the "clasper" or *harpe* was virtually defined by its insertion at the base of Muscle 5 (Flexor of *harpe*), which arises from the base of the valva (usually *sacculus*).

It is true that Forbes mentioned some anomaly of Muscle 5, inserting mostly into *juxta* in place of the *sacculus* in an unidentified and unillustrated species of Geometridae, noting that the "clasper" is missing in this instance. I suspect that here he was dealing with a form of Boarmiinae having the *furca* (Okagaki et al., 1955), in which the *sacculus* is modified into a *juxta*-like structure (= *furca*) and Muscle 5 inserted in the *harpe* has a reversed orientation of the motion transfer as Forbes himself noted. Therefore, I do not see any discrepancy between Forbes (1939) and Sibatani et al. (1954).

In more primitive groups of Lepidoptera (Hepialidae, Incurvariidae, Tortricidae) Muscle 5 is missing. Instead, Muscle 6 (Protractor of aedoeagus) may insert in the base (Tortricinae) or the tip (Incurvariidae and Olethreutinae) of the valva. The origin (or terminus) of this muscle attached to the cephal end of the aedoeagus is very variable even among less primitive families of Lepidoptera, ranging from tegumen or vinculum (the typical case) to various parts of the valva and/or *juxta*. It is therefore conceivable that Muscle 6 may occasionally be mistaken for Muscle 5 or its derivative.

It is also important to notice that the *harpe* (and its Muscle 5) appears predominantly in more specialised groups and not in primitive forms, so that its derivation must be only secondary. This concept would be useful for determining the homology of the valva with more general structures. I shall discuss this subject more fully in a separate paper of this series.

Birket-Smith (1965) divided the valva of Lithosiinae into the following portions: *basis valvae* (including *processus momenti* and *supra-valva*), *ala valvae*, *plica centripetalis* and *valvella*. A careful examination of his text and figures clearly indicates that the musculature in this group is essentially the same as observed by Forbes (1939) and myself (Sibatani, in prep.). Only in minor special groups unusual sclerites like those called the *valvella* with its unusual muscles seem to appear. However, such cases can be recurrently observed in widely scattered groups of Lepidoptera.

The division of the main body of the valva into *basis valvae* and *ala valvae* seems to have been worked out from the particular pattern of sclerotisation of the valva in Lithosiinae, but this should have a more functional rather than fundamentally morphological significance. Thus the following assignment of synonymy is easily made. Assignment similar to that used in the Glossary of Tuxen (1970) is marked with an asterisk.

*Ala valvae* = Sacculus + harpe + their corresponding wall on the outer surface of valval sclerite.

*Basis valvae* (s.str.) = Basal portion of the outer wall of the valva.

*Plica centripetalis* = *Ampulla*.

*Processus momenti* = Unconnected *transtilla*, acting as apodeme for muscular attachment.\*

*Supravalva* = *Cucullus*.

*Valvella* = A structure peculiar to the group studied.

Therefore, Birket-Smith's new system of nomenclature does not enforce a drastic revision of the nomenclature for the division of the valva applicable to more specialised groups. Since the subdivision proposed by Sibatani et al. (1954) was concerned solely with the structures appearing on the mesal surface of the valva, and if the subdivision of the outer surface is called for, Birket-Smith's terms of *basis valvae* and *ala valvae* might prove useful. However, the variation among different families is so enormous that I doubt that a generally workable system can be derived from his terminology.

### Proposed Addenda to Glossary

Only those terms which the author and his former collaborators are responsible for naming and interpreting are listed.

**Cochlear** (-is, ia) ♂ Lep. Ogata 1950, Ogata et al. 1957. Median process of gnathos. → *Brachia*.

**Fenestrul'a** (-ae, -ae) ♂ Lep. Ogata et al. 1957. Dorsal median hyaline part of conjunctival membrane between sociuncus and tegumen. → *Lateral fenestrula*.

Syn. Okontse (= Okonze) Kuznetsov (= Kusnezov) 1916.

— ♂ Lep. Inoué and Kawazoe 1964 in Hesperiidae. Entire sclerotised or unsclerotised conjunctival membrane between tegumen and sociuncus. → *Okonze* Ogata 1950 nec Kuznetsov (= Kusnezov) 1916.

**Furc'a** (-ae, -ae) ♂ Lep. Okagaki et al. 1955, Pierce 1914 in Geometridae (*Ourapteryx*, *Plagodis*, *Cepphis*, *Epione* etc. nec *Ennomos*). Sacculus becoming an independently movable process between juxta and harpe-valvula area of valva; sometimes asymmetric and even unilateral.

**Okontse** (russian) ♂ Lep. Kuznetsov (=Kusnezov) 1916. = *Fenestrula* Ogata et al., *Okonze* Ogata 1950 (part.).

**Okonze** (russian) ♂ Lep. Kusnezov 1916 = *Okontse* Kuznetsov 1916. — ♂ Lep. Ogata 1950. Entire conjunctival membrane between sociuncus and tegumen. → *Fenestrula*, *Lateral fenestrula*.

**Lateral fenestrula** ♂ Lep. Inoué and Kawazoe 1965 in Riodinidae and Lycaenidae. Lateral hyaline parts of the conjunctival membrane between sociuncus and tegumen at the base of brachia. → *Fenestrula*. Syn. Lateral window Shirôzu and Yamamoto 1956.

**Lateral window** ♂ Lep. Shirôzu and Yamamoto 1956 = *Lateral fenestrula*.

**Scaphium** ♂ Lep. Ogata et al. 1957, Gosse 1882 = *Sociuncus*.

**Sociuncus** (-i, -i) ♂ Lep. Sibatani 1972 (this paper). Dorsal appendages of tenth somite as a morphological unit; probably homologous with pygopods; may be further divided into uncus and socii.

Syn. Scaphium Ogata et al. 1957 nec Pierce 1909.

### SUMMARY

A new term "sociuncus" was introduced for the entire dorsal appendage of the 10th somite of male Lepidoptera, of which the uncus and socii are parts. The subdivision of the valva was reexamined in the context of Klots's view in Tuxen's "Taxonomist's Glossary of Genitalia in Insects," Second Enlarged Edition (1970), with the conclusion that no alteration is necessary for the system proposed in a previous paper of this series. The "Glossary" was supplemented by a "Proposed Addenda" to it, which lists some names treated inadequately or missing therein.

### ACKNOWLEDGMENT

My hearty thanks are due to Mr. D. P. Sands, Newport, N.S.W., for his critical reading of the manuscript.

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## ANOTHER LARVAL FOODPLANT FOR *EUPHYDRYAS PHAETON* (DRURY) (NYMPHALIDAE)

During the first week of June, 1971, I was collecting in a meadow in lower Orange County, New York State, where I had collected *Euphydryas phaeton* (Drury) in other years. This year the season was about one week late and very few of the checkerspots were flying. Numerous mature larvae were identified, however, (about two dozen) feeding on scattered bushes of the arrow-wood (*Virburnum recognitum* L.). This shrub was fairly plentiful in this field. Usually there were two to three larvae on a bush, feeding on the uppermost leaves. Though turtlehead (*Chelone glabra* L.) was also present in this field, no caterpillars were seen feeding on it.

It is to be noted that a few days earlier in Andover, Sussex County, New Jersey, a mature larva of this same butterfly was collected on White Ash (*Fraxinus americana* L.).

In 1969, Joseph Muller reported a new larval foodplant for *Euphydryas phaeton*, namely *Pentstemon hirsutus* (L.) (J. Lepid. Soc. 23: 48). Apparently there are several plants which are accepted by mature *phaeton* larvae. As *phaeton* is known to form colonies on turtlehead in its earlier instars, perhaps its diet becomes more catholic with maturity. Perhaps also the requirements of the larger caterpillars may outstrip the availability of the original foodplant, forcing a change.

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## BOOK REVIEWS

CENTURIE DE LÉPIDOPTERES DE L'ÎLE DE CUBA, by Ph. Poey. 1832. I-XII + (1) - (4) + [1-50], 20 coloured plates. Reprinted "1970" [1971] by E. W. Classey Ltd., Hampton, Middlesex. Distributed exclusively in North America by Entomological Reprint Specialists, P.O. Box 77971, Dockweiler Station, Los Angeles, California 90007. Price \$30.00 U.S.

This is another in the series of excellent reproductions of significant entomological books being produced by E. W. Classey Limited. The original has long been excessively rare. Though it contains descriptions and figures of only 20 species, the work having lapsed after the publication of the first two "decades" of the "Centurie," the selection is of such common, interesting or striking forms that the work has commanded widespread attention. Such well-known species as *Eumaeus atala*, *Phoebis orbis*, *Cocytius duponchel* and *Eurema dina* were described here for the first time and five genera were described as new, including the pyraustine genus *Syllepsis*, of which I have had the pleasure of describing several new species in recent years, and *Acrolophus*, now recognized as the type-genus of the family Acrolophidae.

The reproduction appears excellent, though I do not have a copy of the original available for comparison. Care has been taken to work from an example with a good set of plates; one or two inaccuracies have been introduced in the course of partly correcting deterioration in the original pigments, but these are carefully noted in the introduction. The letterpress is clear and clean, though the texture of the paper is somewhat unpleasantly smooth and plastic-like. The introduction by C. F. Cowan is concise but scholarly and informative and has been combined harmoniously by the typesetters with the main text. The cloth binding is neat and attractive, but some will find the chrome yellow dust jacket, with white bands and red lettering and ornament, somewhat overpowering.

The price may seem rather high for a volume dealing with so few species, but considering the historical importance and previous scarcity of the work and the good quality of the reproduction, the market will undoubtedly justify the publisher's judgment.

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A MONOGRAPH OF THE ITHOMIIDAE (LEPIDOPTERA). PART IV. THE TRIBE NAPEOGENINI FOX, by Richard M. Fox and Herman G. Real. 1971. 368 p., 352 fig. Memoirs of the American Entomological Institute, Number 15.

The Napeogenini exhibit Müllerian mimicry and parallel evolution. The relationships of individual species are so complicated that identification by non-specialists has been almost impossible in the past. This reference book provides keys to all of the species and subspecies and should open up this tribe of butterflies to the non-specialist. To somebody who has not previously worked with the Ithomiidae, the keys may appear complicated at first, but considering the insects that they deal with, I think they should prove more than satisfactory to most users.

The monograph treats 7 genera, 104 species and over 300 subspecies. One genus, *Aremfoxia*, is described as new, along with 12 new species and 30 new subspecies. Each species and subspecies is described and keyed, and most are depicted in black and white plates. Annotation includes citations of original descriptions, synonymies and distributional data. Biological data (life histories, behavior, habitats, etc.) are at a minimum.

To fully appreciate this monograph, some knowledge of the extenuating circumstances surrounding its publication is required. With the manuscript about 75% com-

pleted, Richard Fox died suddenly on 25 April 1968. The task of completing the monograph and preparing it for publication was left to his widow, Jean W. Fox, and Herman G. Real, a graduate student who had just arrived in Pittsburgh to study under Fox. Further complications resulted when Mrs. Fox died on 10 March 1970 with the final manuscript still being drafted. About this same time, Real returned to California and the task of final proof-reading fell largely upon George E. Wallace. In view of these circumstances, the overall quality of the treatment is remarkable. The problems presented by a combination of posthumous and joint authorship are fairly well overcome, by having those parts of the text that were not written by Fox clearly indicated as such. New taxa described are variously credited to Fox, to Real, or to Fox and Real.

The four parts in this series of monographs on the Ithomiidae have been published in four different publications. A very high level of excellence was obtained in part three (the Mechanitini) and by comparison this publication does not measure up too well. It is published by offset printing from typewritten plates and does not have the slick appearance of letter press printing. Range maps and other illustrative materials were eliminated by economic pressures and the annotation is less extensive. These shortcomings do not, however, detract from the scientific usefulness of the publication.

Under the circumstances, this is a remarkable book and it will be a valuable reference to those dealing with Ithomiidae for many years. With four more tribes of Ithomiidae remaining to be revised, it is hoped that Mr. Real will take up the challenge, add his life's work to Dr. Fox's and complete this series.

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LEPIDOPTERA GENETICS, by Roy Robinson. 1971. Int. Ser. Monogr. in Pure and Appl. Biol., Zool. Div., Vol. 46: 687 p., 63 tables and 18 figs.; hardbound. Pergamon Press Ltd., Headington Hill Hall, Oxford, Eng. \$26.50.

This work encompasses an exhaustive review of the literature dealing with the genetics of Lepidoptera published prior to 1966. The author admirably fulfills his purpose "to provide a systematic account on a worldwide basis of genetic and karyological studies with Lepidoptera species." The book is intended as a reference for "any person who is interested in the variation or breeding of butterflies and moths" (i.e.: the amateur, as well as the professional and the specialist).

The book includes a rather rambling, wide-ranging (but informative) Introduction, in which such diverse subjects as 1) color and pigmentation, 2) seasonal and environmental influences, 3) breeding techniques, 4) genetic and sexual aberrations, 5) sex determination mechanisms, 6) hybridization, and 7) procedures of taxonomic nomenclature are briefly discussed. Then follow review chapters on the basics of Lepidoptera Genetics, Elementary Biometry, Population Genetics and Polymorphism, Industrial Melanism, and Mimicry. Each chapter is well-written and lucid, and is more or less self-contained. All are thoroughly referenced.

The next two lengthy chapters present an encyclopedic listing of all species of Rhopalocera and Heterocera about which any genetic information has been published. Many species are superficially treated, merely having been included in the book to indicate the completeness of the literature survey. So little is actually known about the genetics of some of them that they could have been omitted without detracting from the book at all. The arrangement of species is alphabetical, and the genetics of each developmental stage are discussed in turn, whenever information is available.

As the author points out, many of the postulated genetic mechanisms are speculative, because of the sparseness of data upon which they are based. The most thoroughly treated genera include *Colias*, *Erebia*, *Heliconius*, *Maniola*, *Papilio*, and *Pieris* among the butterflies, and *Abraxas*, *Anagasta*, *Arctia*, *Biston*, *Bombyx*, *Celerio*,

*Choristoneura*, *Deilephila*, *Ectropis*, *Galleria*, *Luffia*, *Lymantria*, *Panaxia*, *Philosamia*, *Solenobia*, *Sterrrha*, and *Zygaena* among the moths. (The above list is representative, and not all-inclusive.)

The final chapter on *Karyology of Lepidoptera* consists mainly of a 27-page table, listing alphabetically by genera, all species for which the haploid chromosome number has been determined. This table includes the references for each observation. The chapter concludes with a number of comments and observations dealing with meiotic theory under topics such as "polyploidy and the fusion/fragmentation concept, chiasmata frequency, supernumerary chromosomes, and sex chromatin."

One of the most important parts of the book is its comprehensive 60-page Bibliography. All references I examined are accurately cited. Author, subject, and species indexes also are included, and represent a most useful feature of the book. The tables and figures are presented clearly, and usually can be interpreted without reference to the text. Very often they summarize information published in greater detail elsewhere, in order to indicate the trends shown by the data. However, the book does lack a list of tables and figures.

The author's style, although somewhat verbose, provides interesting reading. The book is clearly worded and his statements are for the most part accurate. The author has gone to considerable length to point out to the reader both flaws in the existent data and important problems in need of further investigation. For a work of this size the book contains remarkably few typographical errors.

The organization of the book is perhaps its greatest drawback. In his discussions of topics such as Polymorphism, Industrial Melanism, and Mimicry, the author has tended to follow an historical approach in reviewing the literature. The result of this is a somewhat lengthy "hodge-podge" presentation. I should think that the author's rather dreary alphabetical listings of genetic information on the Rhopalocera and Heterocera could have been better supplanted by family groupings or some other more scientific format.

Unfortunately, certain portions of the text already seem to have been somewhat outdated by research done since 1966. Nevertheless, there are several references cited bearing 1967 and 1968 dates.

Concerning the author's purpose, as stated in the Preface to the book, I believe this work will provide a very handy reference for the specialist and the professional, but I think that the biometric, statistical, and genetic theories and methods contained in the book are so complex that they will be difficult for one not previously trained in these areas to master. Nevertheless, the book does "fill an important gap in the entomological literature," by bringing together and summarizing in readily comprehensible form a considerable amount of information on the genetics of Lepidoptera.

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THE BUTTERFLIES OF WISCONSIN, by James A. Ebner. Milwaukee Public Museum Popular Science Handbook No. 12. 205 p. Available from the Milwaukee Public Museum for \$5.00.

This book has an impressive appearance, is well printed and has an excellent format, reminiscent of F. M. Brown's *Butterflies of Colorado*. A total of 139 species is treated, including ten hesperids considered questionable for Wisconsin, and *Limenitis arthemis* being regarded as a distinct species from *Limenitis astyanax*. Each of these is illustrated with black and white photographs and discussed in about a page of text. The book is well indexed and includes the usual introductory chapters on butterfly morphology, taxonomy and collecting techniques.

On reading the book, it becomes apparent that the author has not collected extensively statewide in Wisconsin and as a result information regarding the northern and

western counties is quite sparse. Many species, especially bog inhabiting ones, that are locally abundant in northwest Wisconsin are given very ineffectual treatment. *Polygonia satyrus* is omitted entirely, although being fairly common from Sawyer county northward. *Satyrrium caryaevorus* is not mentioned, although the photographs of *Satyrrium calanus* (page 64) appear to be erroneously identified as *caryaevorus*. *Colias interior vividior* Berger, the only butterfly with a Wisconsin type locality, receives no mention at all.

The author has not attempted to delineate Wisconsin subspecies, stating that, "Subspecific designations for some Wisconsin butterflies have been omitted awaiting study and clarification." However, with only a few species given subspecific designations, five are incorrectly cited. *Coenonympha tullia inornata* is treated as *C. inornata benjamini*; *Oeneis jutta ascerta* is treated as *O. jutta ridingiana*; *Agraulis vanillae incarnata* is treated as *A. vanillae nigrior*; the unnamed Wisconsin population of *Lycaeides argyrognomon* is treated as *L. argyrognomon scudderii*; and *Boloria selene* is treated under *atrocostalis*, which does occur in northern Wisconsin, however southern Wisconsin populations, and very obviously the specimen figured as *atrocostalis*, are subspecies *myrina*.

This is the first publication to treat all of the butterflies of Wisconsin on a statewide basis. It is a book which has been needed for a long time and which will be in use for many years. It is unfortunate that more extensive and detailed "statewide" collecting records could not have been included.

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## NOTES AND NEWS

### Errata

In the paper by E. M. Shull and F. Sidney Badger, "Annotated List of the Butterflies of Indiana, 1971" (Vol. 26 (1): 13-24), the family name LYCAENIDAE was inadvertently omitted on p. 18 (between **Swamp Metalmark** and **Coral Hairstreak**). Also, on p. 17, the subspecific name of *Pieris napi* should be *oleracea* (not *oleracoa*).



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——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. Adv. Genet. 10: 165-216.

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29 September 1972

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by CYRIL F. DOS PASSOS

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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## THE GENUS *ZESTUSA* (HESPERIIDAE) IN EL SALVADOR WITH DESCRIPTION OF A NEW SPECIES

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The genus *Zestusa* Lindsey, 1925, a replacement name for *Plestia* Mabille, 1888, which is a junior homonym of *Plestia* Stal, 1871, includes two species: *Z. dorus* (Edwards), 1882 and *Z. staudingeri* (Mabille), 1888, the type. *Z. staudingeri* is further subdivided by Evans (1952) into two subspecies: the nominate and *elwesi* (Godman & Salvin), 1893. Approximate geographic ranges of the three forms have been reported as follows:

*Z. dorus*—Southwestern U. S. to northern Mexico (Sonora)

*Z. s. elwesi*—Mexico (Vera Cruz)

*Z. s. staudingeri*—Mexico (Chiapas) to Guatemala

Very little has been published relating either directly or indirectly to the butterflies of El Salvador. Distribution data for *Zestusa* (= *Plestia*) published by Godman & Salvin (1893), Draudt (1921) and Evans (1952) do not mention El Salvador, nor were any *Zestusa* species listed by Franz and Schröder (1954). The recent discovery in El Salvador of two *Zestusa* species, *s. staudingeri* and a new species described below, therefore constitutes a new distribution record for the genus.

Both of these insects were found in the cloud forest of the Hacienda Montecristo near the summit of Cerro Miramundo which marks the common corner of El Salvador, Guatemala and Honduras. Fifteen males and one female of the new species and 53 males of *Z. s. staudingeri* were taken during late February and March, 1970 through 1972 at 2300 m.

The examples of *Z. s. staudingeri* from Miramundo match the figure in Godman & Salvin (1893) very closely and fit quite nicely in the key of Evans (1952) although some specimens show traces of the hyaline spots in spaces 4 and 5 of the forewing that are typical of *Z. s. elwesi*, perhaps



Figs. 1 & 2. Upper and under side of *Zestusa levona* Steinhauser, holotype male, Hacienda Montecristo, Cerro Miramundo, Cloud Forest, El Salvador, elev. 2300 m. 27 February 1971 (S. R. & L. M. Steinhauser). Natural size.

indicating a clinal variation between the two forms. The figure of *elwesi* in Seitz (Draudt, 1921) is somewhat exaggerated; the yellow discal and submarginal markings of the upper side of the hindwing as illustrated are entirely too regular and sharply defined. *Z. s. staudingeri* is not figured. The male genitalia of the Miramundo specimens differ somewhat from the sketch in Evans (1952) which is undoubtedly of *elwesi* as there were no examples of *staudingeri* in the British Museum (Natural History) at the time he prepared his catalogue. Unfortunately he did not illustrate the uncus, thus implying that it is nearly identical to that of *Z. dorus* which is illustrated; Godman & Salvin's figure shows only the lateral view. Because of this I have included a sketch of the genitalia of *staudingeri* from Miramundo (Fig. 4). The principal difference from *elwesi* lies in the greater caudal production of the cuiller and generally narrower clasp of *staudingeri*. The genitalia of 31 males examined showed very little individual variation.

The new species, which I am pleased to name *levona* in honor of my wife, a very able and most enthusiastic collector, is described below. Apart from substituting penis for aedeagus, the morphological and structural terms of Evans (1952) have been adopted.

### *Zestusa levona* Steinhauser, new species.

#### MALE

**Wing Measurement:** Forewing, base to apex, 20 mm (range of 19–21 mm in 15 type specimens).

**Upperside (Fig. 1):** Forewing with pronounced costal fold; color dark brown with red-bronze reflection, slightly darker toward termen with bronze hairs on basal and discal areas; fringe dark grey-brown. Small white hyaline spots in discal area: two (upper and lower) usually separate but occasionally narrowly conjoined in space 2 just distad origin vein 3; sometimes minute dot space 1b immediately behind outer

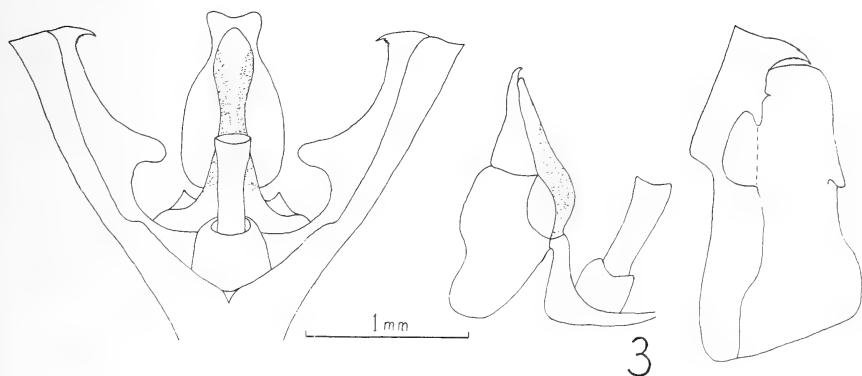


Fig. 3. Male genitalia of *Zestusa levona*, paratype; specimen not dissected. Ventral view (left) shows relative position of opened claspers to uncus, gnathos and penis.

edge of lower spot space 2; narrow straight dash space 3 normal to vein 3 well separated distad from spots space 2; generally three pre-apical spots in straight line nearly normal to costa spaces 7 (may be absent) 8, 9 and fourth (may be minute or absent) space 6, displaced distad; may be minute upper spot space 4 behind spot in space 6; upper cell spot basad of spots in space 2, usually extending more than halfway across cell but may be minute; small spot near base space 11 behind costal fold.

Hindwing with short ( $\pm 5$  mm) tail along prolongation vein 1b; cell weakly closed, vein 5 present but vestigial, marked by well defined crease. Color same dark brown as forewing but with diffused yellowish-ochreous discal stripe, more sharply defined basad, crossed by dark veins and zig-zag dark line distad of origins veins 4 and 6. This pale discal area tapers from vein 6 or 7 where very diffuse to vein 1b where terminates in more sharply defined point just forward of base of tail. Fringe at inner anal angle dark brown, sharply contrasting with pale yellow to white fringe of tail and rear half termen; on forward half of termen checkered with dark brown at vein ends and grading to completely brown at apex. Fringe on tails long (2 mm). Costal area thinly covered dark brown hairs; dorsum densely covered pale tawny hairs.

**Underside** (Fig. 2): Forewing dark brown; same hyaline spots as upper side surrounded by diffuse haloes of slightly darker brown; scattered ochreous-yellow super-scaling more concentrated along costa above vein 12, beyond end of cell in spaces 4 and 5 forming vague paler spot, and in space 1b forming indistinctly divided spot behind and basad of hyaline spot in 1b. May be additional small white spot on costa in space 12 adjacent to spot in 11.

Hindwing as upper side but discal pale stripe more sharply defined, pale yellow, extending from vein 8 to vein 1b, widest (4 mm) in 5 and 6, containing four small dark brown spots in spaces 3–6, those in 5 and 6 offset distad. Detached diffuse pale spot space 7 basad of discal stripe and yellow super-scaling in basal wing area.

**Body:** Head, thorax and abdomen dark brown; thorax and abdomen densely clothed tawny hairs above, yellow-tawny hairs beneath; abdomen beneath ringed pale yellow at each segment. Head above with mixed pale yellow and dark brown hairs. Palpi porrect, hairy, dark brown above with some pale yellow hairs and scales, white beneath with some black hairs; cheeks white.

Legs brown with pale scaling, densely hairy; mid and hind tibiae smooth; mid tibiae single pair spurs; hind tibiae two pairs. Antennae longer than half costa, reaching beyond origin vein 11; shaft black, plain below, some yellow checkering near base above; club broadly arcuate, pale yellow beneath; nudum 19–22 brown.

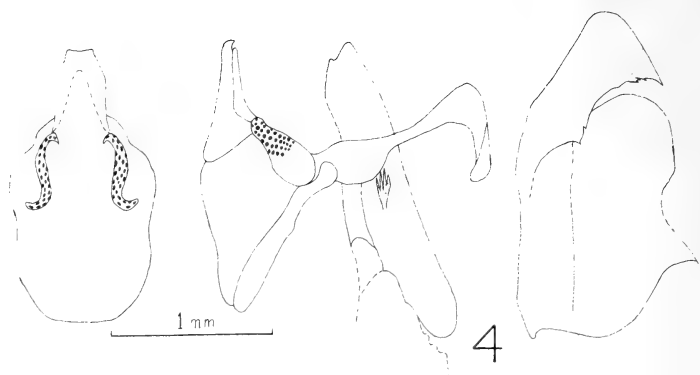


Fig. 4. *Zestusa staudingeri staudingeri* (Mabille), male genitalia of specimen from Cerro Miramundo, El Salvador, 18 March 1971 (S. R. & L. M. Steinhauser).

**Genitalia** (Fig. 3): Uncus weakly bi-lobed, narrow; gnathos laterally sclerotized, non bi-furcate; penis relatively broad and blunt. Clasps symmetrical, cuiller projecting to sharp serrated dorsal tooth, its ventro-caudal apex right angled and sharp; valva with short inward-pointing dorsal projection.

#### FEMALE (Fig. 5)

**Wing Measurement:** Forewing, base to apex, 22 mm. Both wings slightly broader than male.

**Upperside:** As male but forewing spots all present and larger. No fold.

**Underside:** As male but forewing spots as above with additional faint sub-apical spot in 5; hindwing as male but pale discal stripe wider (5 mm).

**Body:** Head, thorax, abdomen, legs as male; antennae as male, nudum 22.

**Type Material:** Holotype, male, Hacienda Montecristo, Cerro Miramundo, Cloud Forest, El Salvador, elev. 2300 m, 27 February 1971 (S. R. & L. M. Steinhauser), No. H-1124, in the U.S. National Museum, Washington, D.C. Fourteen male paratypes, same location (type locality) and collector, 7 March 1970 (Nos. H-223, H-224); 27 February 1971 (No. H-1125); 13 March 1971 (No. H-1168); 18 March 1971 (No. H-1234); 4 March 1972 (No. H-4185); 5 March 1972 (No. H-4186); 25 March 1972 (Nos. H-4288, H-4289) and 26 March 1972 (Nos. H-4291 through H-4295) are deposited as follows: one in the American Museum of Natural History, New York; one in the Carnegie Museum, Pittsburgh; one in the British Museum (Natural History), London and 11 in my own collection. The allotype female, same location and collector, 26 March 1972 (No. H-4290) will remain in my own collection.

*Z. levona* is strikingly different in habitus (Figs. 1, 2, 5) from the three previously known forms of *Zestusa* and can be recognized immediately by the pale yellow stripe and prominent, white-fringed tail of the hindwing. The male genitalia (Fig. 3) have a slightly broader and more pronouncedly lobed uncus than *staudingeri* (Fig. 4); the cuiller is ventrally right angled rather than smoothly rounded and the valva is longer and has an inwardly curved dorsal projection.



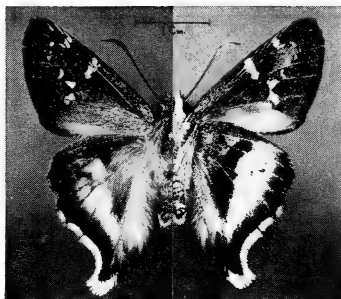


Fig. 5. *Zestusa levona* Steinhauser, allotype female, upper and under side; Hacienda Montecristo, Cerro Miramundo, Cloud Forest, El Salvador, elev. 2300 m. 26 March 1972 (S. R. & L. M. Steinhauser). Natural size.

### Biological Notes

The isolated cloud forest of Cerro Miramundo covers an estimated 20 sq. kms. of the frontier zone between El Salvador, Guatemala and Honduras, extending down from the peak (2418 m) to about 2100 m. Being the sole remaining patch of virgin cloud forest in El Salvador, it affords a unique site to explore the distinctive and restricted insect fauna associated with this environment. Of the 114 butterfly species so far known from there, 35 have not yet been found elsewhere in El Salvador. Because of the extremely dense forest growth, collecting is virtually impossible except in clearings or at the edge of the forest.

The observed flight season of *Zestusa* at Miramundo does not extend beyond February, March and April; despite good collecting conditions and careful search, none were found on 23, 24 January or 8, 9 May 1971. Unfortunately it was not possible to visit the area between 18 March and 8 May 1971, and the earliest good weather conditions encountered after January 1971 were on 27 February. Only one collecting trip (7 March) was made between January and November 1970. No *Zestusa* were found 12–15 February 1972 but collecting was good for both species during 2–5 and 25–26 March 1972.

Although both species were found in the same limited area at the same time, their habits are quite different. *Z. levona* was observed only either in flight (approx. 7 m) or visiting flowers. One female and 14 males were taken on the pale lavender blossoms of a tree of the family Asteraceae identified by T. F. Hall as *Ageratum* sp. close to *rugosum* Coulter. Standley and Calderon (1925) describe *rugosum* as generally less than one meter high, whereas this tree grows up to five meters. One male was taken from the purple flowers of another tree not yet identified. *Z. s. staudingeri* on the other hand, was never found visiting flowers. One

specimen was taken while drinking from a damp spot on a vertical rock face (tuff) along with a male hesperiid, *Doberes anticus sobrinus* (Godman & Salvin), 1895. Aside from this, it was observed only in a "territorial defense" position on leaves or bare twigs of various trees along the road, whence it frequently sallied forth in a rather leisurely "inspection" flight, covering up to 20 meters in each direction before returning to its observation post, or in rapid attack flight against other passing skippers. It never was seen to attack other insects or even butterflies of other families though many flew past. It frequently could be induced to investigate a net waved to and fro resulting in its capture, although it often found my head a more interesting subject, circling so close as to make capture impossible.

Despite these differences in habits and the much less extensive nudum of the antennal club (21 segments instead of the 34 mentioned by Evans (1952) as a character of the genus), the porrect palpi, very hairy legs, broadly curved antennal club and general aspect of the genitalia place *levona* quite clearly in the genus *Zestusa*.

#### ACKNOWLEDGMENTS

I am very grateful to Col. S. S. Nicolay for his helpful advice and suggestions and to Mr. H. A. Freeman for confirming Col. Nicolay's opinion that *Z. levona* had not been described. I am also indebted to Dr. Thomas F. Hall for identifying the tree whose flowers are so attractive to *levona*, to Dr. Sam Breeland for his critical review of this manuscript and to Don Ernesto Freund, owner of the Hacienda Montecristo, for allowing us access to his property to collect insects.

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SOME OBSERVATIONS ON THE LEPIDOPTERA OF  
BROMELIADS

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The bromeliads are mostly tropical plants, with leaves generally arranged in rosettes which permit the accumulation of water and detritus; these form a microhabitat suitable for many organisms, principally insects, whose different interrelations constitute special ecosystems of great biological interest (Picado, 1913; Smith, 1938).

Compared to other groups of insects inhabiting these plants, Lepidoptera are scarce. Thus, in his masterly work "Les Bromeliacees epiphytes considerees comme milieu biologique," Picado (1913) reports only two species: *Valentinia bromelia* Walsing. (Blastobasidae) from Córdoba, Veracruz, México, and *Acrolophus pallidus* Möschler (Acrolophidae) from Costa Rica. He reports the larvae as living among the leaves of *Aechmea* and other large bromeliads. Biezanko (1961) reports four moths from bromeliads in Rio Grande do Sul, Brazil: *Castnia acraeoides* Gray, *C. boisduvali* Walker, *C. garbei* Fortterle and *C. satrapes catharina* Preiss, collected in *Tillandsia aëranthos* (Loisel) L. B. Smith, *Bromelia antiacantha* Bertol and *Ananas comosus* (L.) Merr.

In Mexico I have collected the following species in bromeliads—arrangement according to Hoffmann's Catalogue (1940):

*Melinaea imitata* Bates (Danaiidae). A chrysalis was found in a leaf of *Aechmea bracteata* (Swartz) Griseb (Fig. 1.), at the Tropical Biological Station "Los Tuxtlas," near Sontecomapan, Veracruz. This species we consider only occasional, since larvae have not been found feeding on this plant, although all known Ithomiidae feed on Solanaceae as larvae.

*Napaea eucharilla picina* Stichel (Riodinidae) (Figs. 7-8). Caterpillars were found eating the leaves of *Aechmea bracteata* (Swartz) Griseb, and *Aechmea nudicaulis* var. *nudicaulis* L. B. Smith, collected at the "Los Tuxtlas" Station.

*Caria domitianus ino* Godm. & Salv. (Riodinidae). Larvae eating the leaves of *Tillandsia caput-medusae* E. Morren, collected at San Francisco Acuitlapán, Guerrero; they hatched on 14 June 1971.

*Thecla basalides* Geyer (Lycaenidae) (Figs. 2-4). The caterpillars are a serious pest of pineapple (*Ananas comosus* (L.) Merr.), causing great losses of this crop; they enter the inflorescence and cause an abnormal development, besides facilitating the entry of bacteria and fungi which cause rotting. I have also found these larvae eating the fruits of another



Fig. 1. *Aechmea bracteata* (Swartz) Griseb, a giant bromeliad from Veracruz.

bromeliad, *Aechmea bracteata* (Swartz) Griseb (Fig. 1), in southern Veracruz.

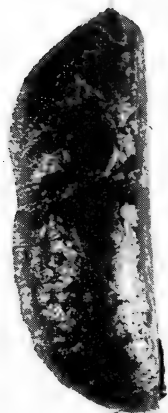
*Thecla hesperitis* Btlr. & Drc. (Lycaenidae). I found larvae eating the leaves of *Tillandsia caput-medusae* E. Morren, which I collected at Acahuizotla, Guerrero; they hatched on 20 June 1970.

*Automeris janus metzli* (Sallé) (Saturnidae). A cocoon was found in an *Aechmea bracteata* var. *pacifica* Beutelsp. at El Rincón, Guerrero. It hatched on 18 August 1971; but this, as well as the next species, is considered a casual occurrence.

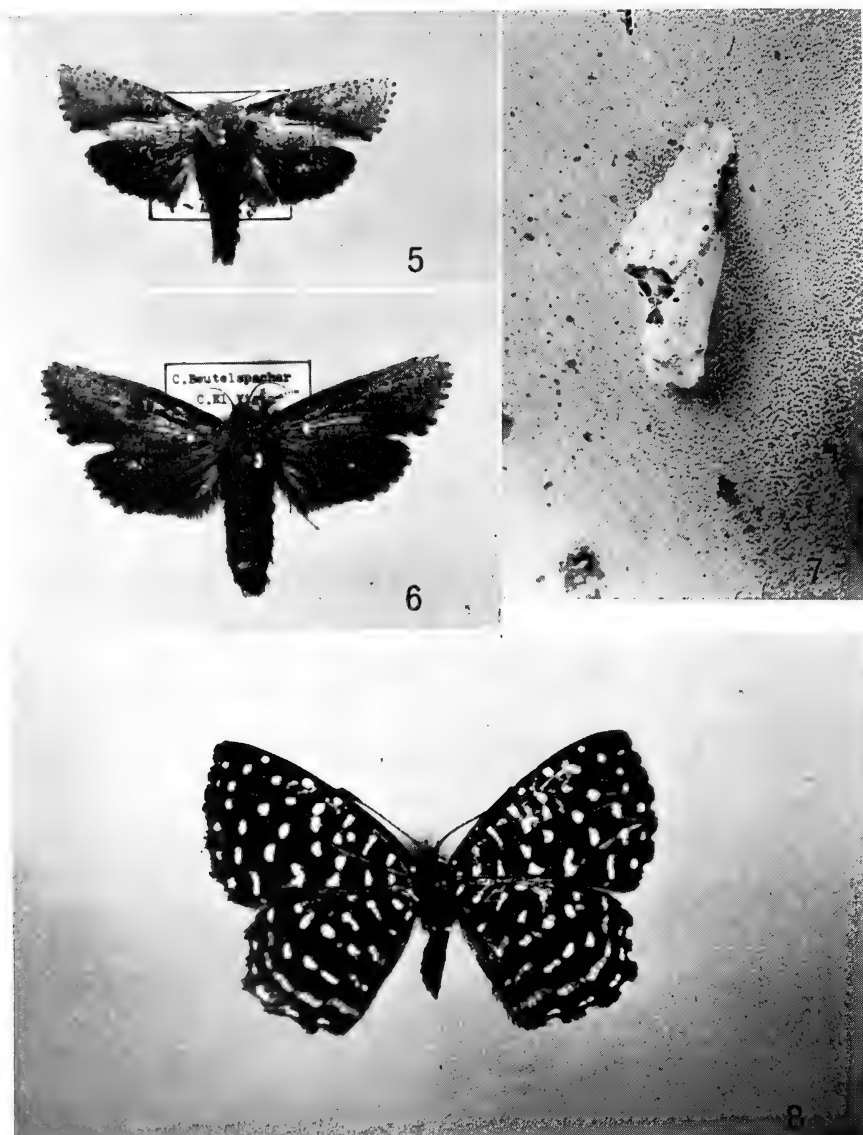
*Urania fulgens* Walk. (Uranidae). A cocoon was found among the leaves of *Aechmea bracteata* (Swartz) Griseb, at the "Los Tuxtlas" Biological Station.

*Ammalo megapyrrha* Walk. and *Ecpantheria* sp. (Arctiidae) found among leaves of the same *Aechmea bracteata* in San Luís Potosí and in southern Veracruz.

*Acrolophus vigia* Beutelsp. (Acrolophidae) (Figs. 5-6). This species was described from larvae cultivated in the laboratory and reared to obtain adults (Beutelspacher, 1969). The larvae were found in *Aechmea*



Figs. 2-4. *Thecla basalides* Geyer (Lycaenidae). 2, egg on fruits of *Aechmea bracteata* (Swartz) Griseb; 3, pupa, lateral; 4, female.



Figs. 5-6. *Acrolophus vigia* Beutelsp. (Acrolophidae). 5, male; 6, female.  
 Figs. 7-8. *Napaea eucharilla picina* Stikel (Riodinidae). 7, pupa; 8, male.

*bracteata* (Swartz) Griseb, in Veracruz and Yucatán, as well as in *Aechmea mexicana* Baker and *Vriesia gladioliflora* (Weindl.) Ant. in the "Los Tuxtlas" region, Veracruz, and in *Vriesia chiapensis* Matuda, from Bochil, Chiapas. The caterpillars feed on bromeliad leaves, and are semi-aquatic in their habits. The adults emerged in February.

I would like to express my thanks to Dr. Allan R. Phillips for English translation of this work.

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## THE EFFECT OF CAUTERIZING THE MNPPM OF THE PUPA OF THE MONARCH BUTTERFLY (*DANAUS P. PLEXIPPUS*) (DANAIDAE)

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The pupa of the monarch butterfly possesses well-defined surface pigmented areas (color plate, e) which, owing to the configuration of the lamellae of the cuticle plus the presence of a yellow epidermal pigment, imparts to them the appearance of golden spots and hence they have been referred to as "gold spots" in the literature. Since "gold spots" is not descriptive of these structures the terminology *prismatic pigmented maculae* (PPM) has been suggested (Urquhart & Tang, 1970).

Since the PPMs are constant in number and position and further since it was suspected that they may perform specific functions, terms have been applied to each pair, the designation of such terms referring to morphological structures of the developing imago (Urquhart, 1960).

As to the possible function of the PPMs, it was suggested that perhaps they acted as "light receptors" controlling in some manner the development of the imago (Urquhart, 1960). However, it was later indicated that light did not appear to have any effect on either the emergence time or the morphological structures of the adult butterfly (Petersen, 1964; Taylor, 1964).

By utilizing a micro-cauterizing technique (Urquhart & Dampney, 1969) the tissues of the lateral ulnar (LU), lateral notal (LN) and median ocular (MO) PPMs were destroyed and it was found (Urquhart and Tang, 1970) that certain areas of the wing became faded (with respect to the treatment of the LUPPM and LNPPM) or that the head lacked scales (with respect to the treatment of the MOPPM).

In the present report the tissues of the median notal MNPPM (Fig. 1) were destroyed. Since the MNPPMs possess a much thinner layer of cuticle, compared to the other maculae which have been previously studied, one series of 25 pupae were treated for 3 secs. fulgurating time and a second series for 5 secs. Both maculae of a pair were treated in some pupae and only one of the pair in others. This was done to compare results of the effect of cauterization on one specimen thus eliminating the possibility of individual variation. Twenty-five pupae were used as controls in which an area remote from the MNPPM, but still within the notal region, was cauterized.

Of the 25 specimens cauterized for 3 secs., none exhibited wing fading, thus indicating that the time period was not sufficient to destroy the tissue of the PPM.

Of the 25 pupae cauterized for 5 secs. fulgurating time, 23 adults emerged and all but two of them indicated varying degrees of wing fading. Fourteen specimens indicated fading in the mesothoracic wings, mostly in the cubital area (Color plate, a- in this particular example only the left MN was treated); one specimen (Color plate, b) indicated fading in both meso- and metathoracic wings; six specimens (Color plate, c) indicated marked fading of the metathoracic and slight fading in the cubital area of the mesothoracic wings; two specimens indicated no discernible fading (Color plate, d). No fading was indicated in the controls.

It has been previously suggested that the PPM might govern wing pigmentation for fairly well-defined areas of the body (Urquhart & Tang,

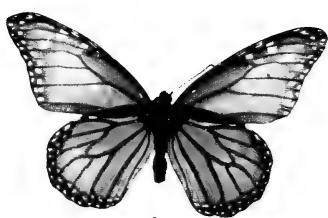
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Color Plate: a, b, c, d—effect on wing pigmentation of cauterization of the MNPPM of the pupa; e—pupa of the monarch butterfly showing the PPMs ("gold spots") on one side.

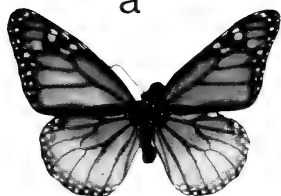




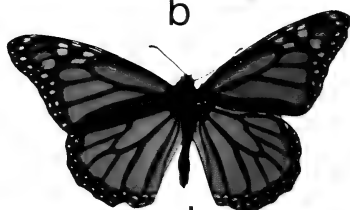
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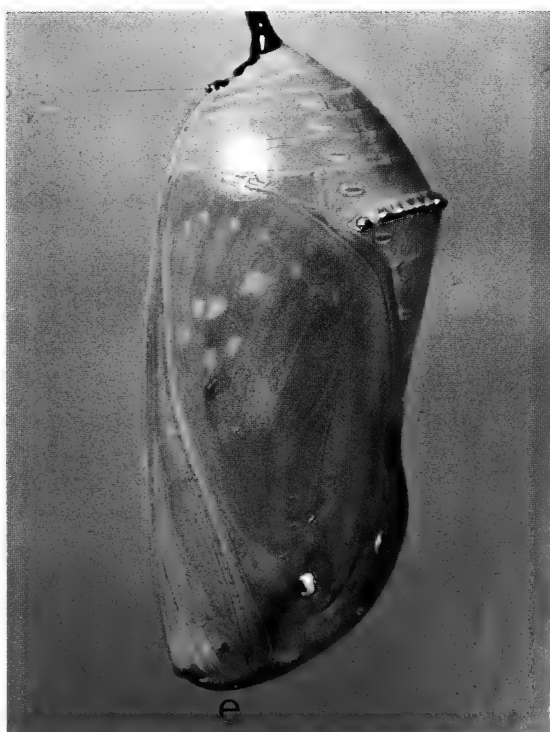
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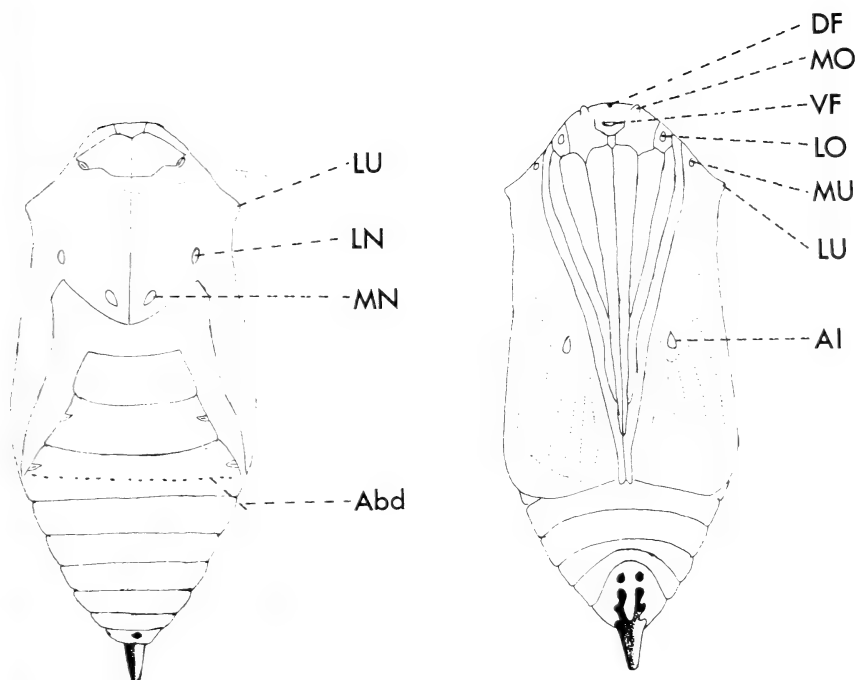


Fig. 1. Abbreviated designations of the PPM: LU, lateral ulnar; LN, lateral notal; MN, median notal; Abd, abdominal; Df, dorsal frontal; MO, median ocular; VF, ventral frontal; LO, lateral ocular; MU, median ulnar; Al, alar.

1970). However, the present experiment would seem to indicate that, although the hind wings became faded as a result of cauterizing the MNPPM, which did not occur with cauterizing the LUPPM and LNPPM, the degree of variation is such as to presuppose an interrelationship between the various PPMs. Thus, one pair of PPMs may govern wing pigmentation in a certain area of the wing, as in the case of the LU and LNPPM, while others, although primarily governing pigmentation in another area, such as the MNPPM and the metathoracic wings, may also affect other areas, such as the mesothoracic wings.

It is not known in what manner the PPMs influence the pigmentation of the scales of the wings nor is it known for what period of time the PPMs remain active in controlling scale pigmentation. In our experiments we have timed the period of cauterization within 24 hours after the appearance of the pupa from the larval skin because our histological studies indicated that the pigment disappeared from the cell cytoplasm after 24 hours and also the morphology of the tissue cells changed so as to be indistinguishable from the surrounding epidermal tissue.

It may be conjectured that PPMs found in the pupae of other families of Lepidoptera will exhibit results similar to those indicated in the present and previous papers.

#### ACKNOWLEDGMENTS

The present investigation, which is part of a large project dealing with the ecology of the monarch butterfly, was supported by grants from the National Geographic Society of the United States and the National Research Council of Canada.

The colour photographs appearing with this paper were taken by David Harford, photographic technician of Scarborough College.

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### CERCYONIS PEGALA BLANCA, A "MISSING TYPE" IN THE EVOLUTION OF THE GENUS *CERCYONIS* (SATYRIDAE)

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Each of the smaller three species of the nearctic *Cercyonis* has a very distinctive whitish race which is adapted to the arid alkaline flats of the western deserts of the United States. *Cercyonis meadi alamosa* Emmel & Emmel occurs in salt flats of the isolated San Luis Valley of south-central Colorado at 8,500 feet elevation (Emmel & Emmel, 1969). *Cercyonis sthenele paulus* Edwards is a white-marked form occurring in extensive populations throughout the western portions of the Great Basin between the Rockies and the Sierra Nevada. *Cercyonis oetus pallescens* Emmel &

Emmel, an extraordinary form with whitish ventral surface, inhabits the dry alkaline meadows of the Reese Valley in Nevada (Emmel & Emmel, 1971). At the time of this last-mentioned publication, it was thought that the closest analogous phenotype in the large *Cercyonis pegala* complex was *C. pegala gabbi* Edwards from Utah, which has light undersurfaces.

However, in a remote part of Nevada in late summer 1970, one of us (SOM) discovered a heretofore-unsuspected form of *Cercyonis pegala* Fabricius, which matches for dramatic adaptation of ventral white coloration the previously mentioned smaller *Cercyonis*. The purpose of this paper is to formally describe the new set of populations and to report the unique life history of this subspecies.

### ***Cercyonis pegala blanca* Emmel & Mattoon, new subspecies**

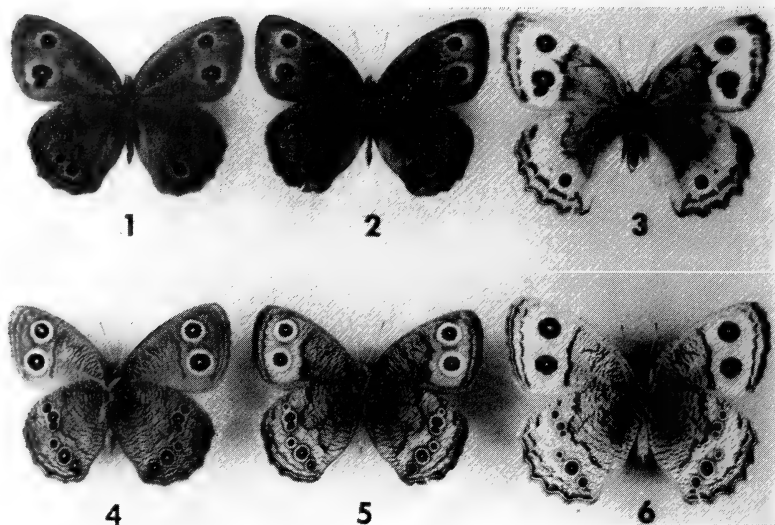
**Holotype, male:** Expanse, 47.8 mm. Forewing length, 16.6 mm. *Forewings, superior surface:* Identical to pattern and coloration of *C. pegala gabbi*, being dark brown with a faint yellow ring around each of two major ocelli. Both major ocelli pupilled with white scales. Occasionally one or two additional minor ocelli, lacking pupils. *Hindwings, superior surface:* Dark brown, with two or more (as many as five) well-marked submarginal ocelli. Large ocellus in cell  $Cu_1$  is almost always pupilled with white scales. *Forewings, inferior surface:* Brown areas (except dark brown striations) present in other *pegala* subspecies are here covered with whitish or light tan scaling. Yellowish rings around major ocelli are broad but not joined as in *C. pegala ariane* f. *stephensi* [♀] Wright (see Emmel, 1969). *Hindwings, inferior surface:* Entire wing except for dark brown striations is heavily suffused with silvery white scaling. Six marginal ocelli present in all males collected. *Head, thorax, and abdomen:* Dark brown on dorsal surfaces, whitish on ventral surfaces. *Genitalia:* As in other *C. pegala* (Emmel, in prep.).

**Allotype, female:** Expanse, 55.5 mm. Forewing length, 31.1 mm. *Superior surface:* Generally similar to the variable dorsal phenotype found in *C. pegala ariane* f. *stephensi* [♀], with a broad yellow submarginal band always found on the forewing and usually present on the secondaries also. The ground color usually quite tannish rather than a dark brown as in the male. Forewing ocellation varying from two to five ocelli, but usually only two major ones and these are always pupilled. Hindwing ocellation very well developed, with as many as six black ocelli ( $M_3$  and  $Cu_1$  ocelli pupilled). *Inferior surface:* Both forewings and hindwings heavily suffused with whitish or silvery white scaling, obscuring all brown areas except principal striations. Forewing-band area is light tan on most specimens. *Head, thorax, and abdomen:* As in male, though lighter on dorsal surface corresponding to lighter color of wings.

**Holotype male:** Nevada, Hwy. 140 at Dufurrena Ranch—Chas. Sheldon Antelope Range, T45N, R26E, Humboldt County, August 21, 1970, S. O. Mattoon, collector.

**Allotype female:** Nevada, Hwy. 140 at Dufurrena Ranch—Chas. Sheldon Antelope Range, T45N, R26E, Humboldt County, August 11, 1970, S. O. Mattoon, collector. Paratypes: 20 ♂♂, 10 ♀♀, same locality and date as holotype, S. O. Mattoon, collector; 8 ♂♂, 20 ♀♀, same locality and date as allotype, S. O. Mattoon, collector.

The holotype and allotype will be deposited in the Florida State Collection at the University of Florida. Pairs of paratypes will be deposited in the following institutions: American Museum of Natural History, Allyn Museum of Entomology, Cali-



Figs. 1-6. (1) *Cercyonis pegala gabbii* male, dorsal surface, from Salt Lake City, Salt Lake Co., Utah, 3 July 1965, Kenneth B. Tidwell, collector; (2) *Cercyonis pegala blanca* Emmel & Mattoon, dorsal surface of holotype male, from the type locality, Humboldt Co., Nevada; (3) *Cercyonis pegala blanca* Emmel & Mattoon, dorsal surface of allotype female; (4-6) ventral surfaces of the above specimens, respectively.

fornia Academy of Sciences, and the Los Angeles County Museum of Natural History. The remainder of the paratypes are being retained by the authors for further study. The subspecific name, *blanca*, is Spanish for "white."

This subspecies differs from previously described forms of *Cercyonis pegala* primarily in its extraordinary white scaling on the undersides of both wings. It is of special evolutionary interest because its development of white scaling matching its unusual white alkaline-flat environment parallels the phenetic changes that have occurred in *Cercyonis meadi*, *sthenele*, and *oetus* under similar environmental regimes. Each represents a terminal point as offshoots of the main stocks of the respective species, and while the existence of *C. pegala blanca* was previously unsuspected it is gratifying to find such a development to complete that particular picture of adaptive phenetic change in the genus *Cercyonis*.

#### Description of the Habitat

This butterfly inhabits the swampy alkaline area around the Dufurrena Ranch sub-headquarters of the Charles Sheldon Antelope Range in Humboldt County, northern Nevada. Thousand Creek Spring feeds this area in a former lake basin surrounded by lava flows. The wet area

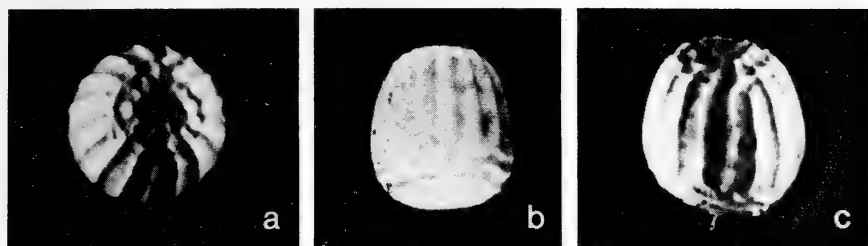


Fig. 7. The egg of *Cercyonis pegala blanca* Emmel & Mattoon: (a) dorsal end, showing micropylar region; (b) ventrolateral view; (c) dorsolateral view.

vegetation is dominated by lush grasses and willows, while wild rye, *Elymus cinereus*, dominates the slightly drier adjacent terrain. The latter species of tall bunch grass is used as a roosting site for *Cercyonis pegala blanca*, while one or more of the shorter grasses and sedges in the wet areas are apparently used for oviposition. These latter grasses include *Eleocharis palustris*, *Juncus balticus*, *J. lescurii*, and *Beckmannia syzigachne*, and the sedge *Carex nebrascensis*. Aside from the springs area the vegetation dominating this arid basin is sagebrush (*Artemisia confertifolia* and *A. truncata*).

### Life History

Living females collected in August 1970 were induced to oviposit in the laboratory of S. O. Mattoon at Chico, California, and the eggs were maintained and larvae reared on commercial-brand blue grass in an outdoor greenhouse there. Techniques were as described by Emmel (1969) in general. All measurements and descriptions of the stages are by the second author.

It is particularly noteworthy that the life history of this Nevadan *Ceryonis pegala* subspecies has only five larval instars (at least under our experimental conditions), whereas Colorado and coastal California *Ceryonis pegala boopis* exhibited six larval instars under constant-temperature conditions (Emmel, 1969). We plan to investigate further this variation in instar number. As in all other *Cercyonis*, this new subspecies diapauses and overwinters in the first larval instar; when the larvae hatch several weeks after oviposition, they crawl to the base of a grass clump and enter diapause without feeding.

**EGG. SHAPE:** Egg 1.1 mm in height, 1.0 mm maximum width; somewhat conical, broader and flatter at base with top more rounded. Adorned laterally by numerous vertical ridges (approximately 19) which intersect and traverse approximately four progressively smaller ridges approaching the top of egg, producing a somewhat scalloped appearance. The vertical ridges terminate basally just below the widest

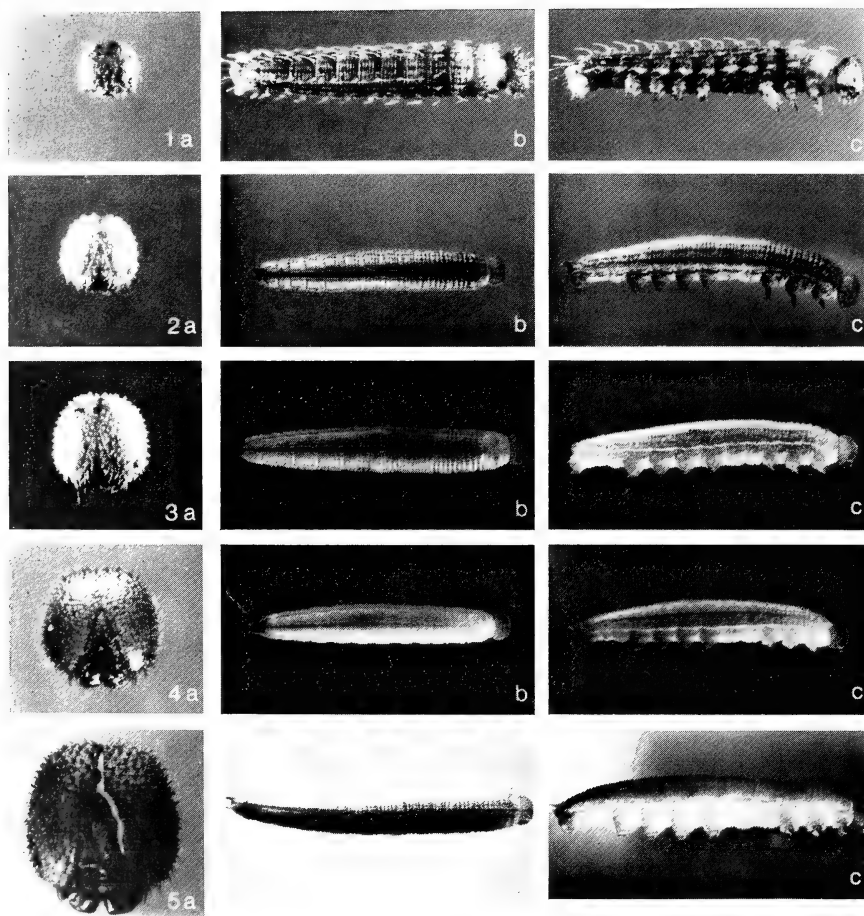


Fig. 8. The five larval instars of *Cercyonis pegala blanca*: (1) first, (2) second, (3) third, (4) fourth, and (5) fifth instars. Head capsule (a), dorsal view of larva (b), and lateral view of larva (c).

portion of the egg and do not traverse another series of similar but more numerous basal concentric ridges. **COLOR:** White at oviposition, turning tan within three days, and lightly marked between the ridges by a sparse mottling of irregularly sized orange-brown spots and splotches during later development.

**LARVAL STAGES. First Instar.** HEAD CAPSULE: Average width, 0.64 mm, height, 0.65 mm (20 larvae). Ground color purplish brown (light brown after ecdysis). Surface retiform, depressions between ridges more darkly pigmented. Antennae (in all instars) light amber, basal area green, distal extremity becoming darkened. Labial and maxillary palpi translucent, darkened distally. Mandibles translucent, cutting edge with broad margin of black. Labrum translucent, notch black. Facial suture margins darkened. Ocelli black. Head capsule setae sparse, piniform, all oriented anteriorly then most curving slightly ventrally (in all instars),



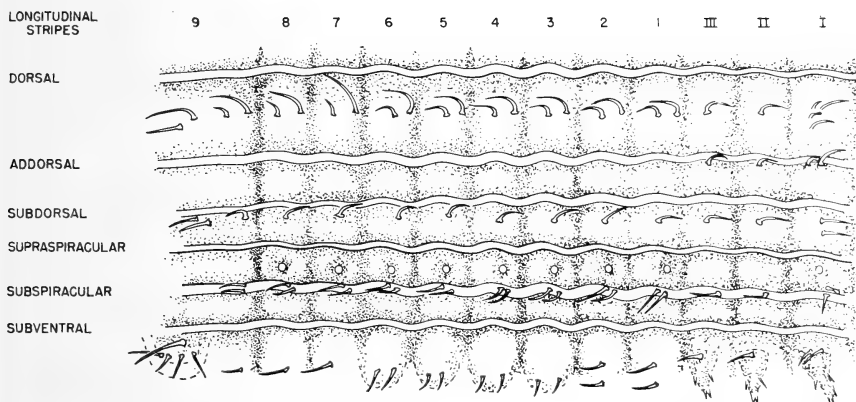


Fig. 9. Map of setal arrangement and pigmented stripes described in text for first-instar larva of *Cercyonis pegala blanca*.

setae long (averaging three times the width of large ocelli), translucent, granular (in all instars), darkened at juncture with head with minute purplish brown chalazae, and in a constant bilaterally paired arrangement. TRUNK: Average length 5.0 mm. First abdominal proleg segment width, 0.85 mm (20 larvae). Ground color of diapausing larva light tan to light brown, turning grass green within 24 hours after feeding. Body segments annulated, five annuli per thoracic and six per abdominal segments, marked by dorsal, addorsal, subdorsal, supraspiracular, and subventral purplish brown longitudinal stripes, and laterally by a prominent greenish white subspiracular stripe. Randomly distributed whitish green pigment spots showing through integument are more concentrated bordering stripes. Thoracic legs faint purplish brown, darkened distally. Claw darkened at juncture with tarsus. A pair of spinose, opposed setae extend beyond claw in all instars. Abdominal prolegs grass green; crochets in a uniordinal uniserial latero-series, colored brownish black. The anal prolegs with purplish brown pigment patch (sometimes obscure) on lateral aspect. Spiracular openings on distal extremity of rusty orange, globe-tipped stalks. Globe with minute transverse ridges running from opening to stalk. Body armed bilaterally by five longitudinal rows of long spiniform setae, some knob-tipped on cephalic margin of first abdominal segment. Setae barely discernable without magnification. Setal arrangement (Fig. 9) is as follows. *Row I*: Located dorsad of the addorsal stripe. Comprised of posteriorly-oriented, horizontally-aligned pairs on each abdominal segment and one seta anteriorly oriented on each thoracic segment, except headed by a group of four (sometimes knob tipped) on cephalic margin of first thoracic segment. *Row II*: Single, anteriorly oriented, spiniform, except paired and sometimes knob tipped on first thoracic segment (row restricted to thoracic segments only), located on addorsal line. *Row III*: Ventrad of subdorsal line. All spiniform, single, anteriorly oriented except posteriorly oriented on abdominal segments nine and ten, and paired on caudal and first thoracic segments. *Row IV*: In subspiracular line, all spiniform (except sometimes knob tipped on first thoracic segments), paired, and posteriorly oriented except on thoracic segments two and three. *Row V*: Located subventrally at leg bases. All posteriorly oriented and paired, except singular on thoracic segments two and three and abdominal segments seven, eight, and nine. Five long, spiniform, ventrally or posteriorly oriented setae arise from within the perimeter of anal proleg color patch. Caudal segment blunt. Long, spiniform, posteriorly oriented, bilaterally paired setae project from conical purplish

brown chalazae on the posterior of caudal segment. The longest pair arise dorso-laterally and appear to extend caudally the tapering body line.

**Second Instar.** HEAD CAPSULE: Average width 1.01 mm, height 0.90 mm (20 larvae). Ground color grass green with faint purplish brown cast (light brown after ecdysis). Capsule surface features as in first instar, except surface reticulations more irregular, the depressions not darkened. Facial sutures only faintly darkened with two dark spots on attachment margin of labrum. Head capsule setae more numerous, minute, strongly knob tipped in cephalic region, averaging one-half the width of large ocellus, becoming more spiniform and longer around frontal portion. Setae not darkened at juncture with chalazae as in first instar. Chalazae white (slightly larger than in first instar) and more bulbous. TRUNK: Average length, 7.8 mm; first abdominal proleg segment width, 1.13 mm. Ground color grass green. In second through fifth instars, integument surface textured with a multitude of minute circular smooth convex areas producing translucent frosted appearance, more pronounced early in instar and lessening as skin tightens. The longitudinal dorsal, addorsal, subdorsal, and supraspiracular solid purplish-brown stripes more obscure than in first instar. Subventral stripe dashed and purplish brown dorsad of leg bases. Subspiracular stripe along the somewhat protruding extreme lateral aspect of trunk well defined and solid white. Body segments more noticeably annulated. Thoracic legs brownish green, tarsal claw and distal half of tarsus darkened. Tibia, femur, and proximal half of tarsus amber brown, coxae green. Abdominal prolegs green, crochets more numerous. Setae on all leg bases strongly knob tipped from minute green chalazae, becoming progressively more numerous and spiniform from smaller chalazae distally. The more distal setae sometimes darkened at attachment with chalazae. Spiracles with stalk much reduced to absent; often, globe incomplete distally, exposing hollow interior with spiracular opening at base. Body setae now numerous, minute (much shorter than first instar, not discernable without magnification in second through fourth instar), irregular but in somewhat poorly defined longitudinal rows. Most strongly knob tipped and posteriorly arching from minute green chalazae except some anteriorly arching; setae longer, spiniform, darkened at juncture with chalazae along cephalic margin of first thoracic segment and along lateral aspect of all thoracic segments. Caudal segment now divided into two posteriorly-projecting, fleshy-rose-colored, short, conical forks, each covered with posteriorly-oriented, short, strongly knob-tipped, slightly rose colored setae.

**Third Instar.** HEAD CAPSULE: Average width, 1.47 mm; height, 1.42 mm (20 larvae). Ground color grass green with very slight brownish cast (brown after ecdysis). Head capsule very similar to second instar, except setae more numerous, chalazae more prominent, bulbous, and white. TRUNK: Average length, 13.5 mm; width at first abdominal proleg segment, 2.00 mm. Ground color grass green, modified especially on dorsal and lateral surfaces between longitudinal stripes by whitish pigmented chalazae of next instar showing through integument. Annulae more strongly pronounced, giving the appearance of minute whitish transverse rings. Longitudinal striping limited to dorsal, subdorsal, and subspiracular lines. Dorsal stripe faint purplish green, central portion almost obscured. Subdorsal stripe area lacks underlying pigment spots, thus appearing translucent grass green with faint yellowish white stripe along dorsal margin. Subspiracular stripe solid white, well defined on the less pronounced lateral aspect of body. Thoracic and abdominal legs grass green, setae as in second instar, thoracic legs darkening distally with tarsus and claw amber brown. Crochets basically biordinal uniserial lateroseries (an apparent biserial condition sometimes results from approximately three of the shorter central crochets being slightly offset from uniserial line, but not enough to be considered biserial). Crochets amber brown, anal proleg series in a biordinal uniserial mesal semicircle. Spiracles rusty orange and each comprised of a prominent circular peritreme raised along central caudal margin into fleshy incurving nipple-like conical projection. Peritreme larger, transverse, and elliptical on first thoracic and eighth

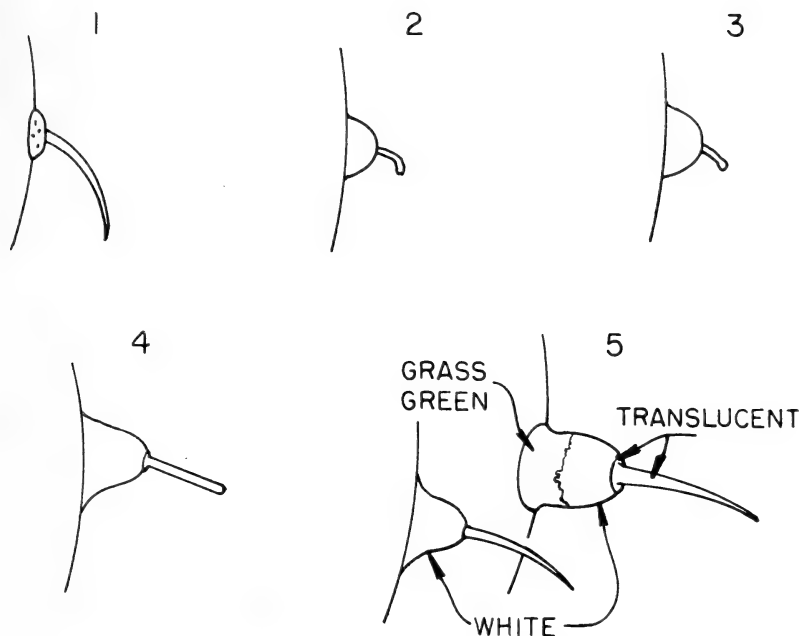


Fig. 10. Details of shape of head capsule chalazae and setae on (1) first instar, (2) second instar, (3) third instar, (4) fourth instar, and (5) fifth instar larvae. Stippled area in (1) is light purplish brown; white areas are pearly white unless otherwise indicated.

abdominal segments. Structure of first thoracic spiracle reversed with raised projection on cephalic margin. Body setae as in second instar except more numerous and randomly distributed, darkened setal bases not as extensive except ventrally where spiniform setae arise from more bulbous white chalazae along leg bases and in groups on corresponding segments lacking legs. Caudal segment as in second instar.

**Fourth Instar.** HEAD CAPSULE: Average width, 2.21 mm; height, 2.27 mm (20 larvae). Ground color grass green (green after ecdysis). Surface with reticulation of ridges connecting chalazae. Ridges less pronounced ventrally. Setae more numerous than in third instar; blunt and spiniform to knob tipped dorsally, becoming predominantly knob tipped ventrally, all arising from slightly more conical, white chalazae. Facial sutures more heavily margined brown, otherwise head capsule as in third instar. TRUNK: Average length, 21.9 mm; first abdominal proleg segment width, 2.94 mm (20 larvae). Ground color grass green. Body setae mostly blunt and spiniform dorsally, knob tipped laterally becoming shorter and strongly knobbed ventrally, all from minute conical green chalazae. Annulations strongly pronounced, integument and setae producing whitish pubescence. Ground color modified late in instar dorsally and laterally, appearing yellowish white due to coloration of developing chalazae beneath integument. Longitudinal striping as in third instar, except dorsal stripe grass green, sometimes faintly bordered yellowish white. Subdorsal stripe lightly defined yellow to greenish white, sometimes bordered dorsad with grass green. Legs as in third instar, except setae are knob tipped on leg bases, becoming progressively more spiniform terminally and in corresponding areas on segments without legs. Some chalazae mostly on lateral aspect of thoracic leg bases darkened

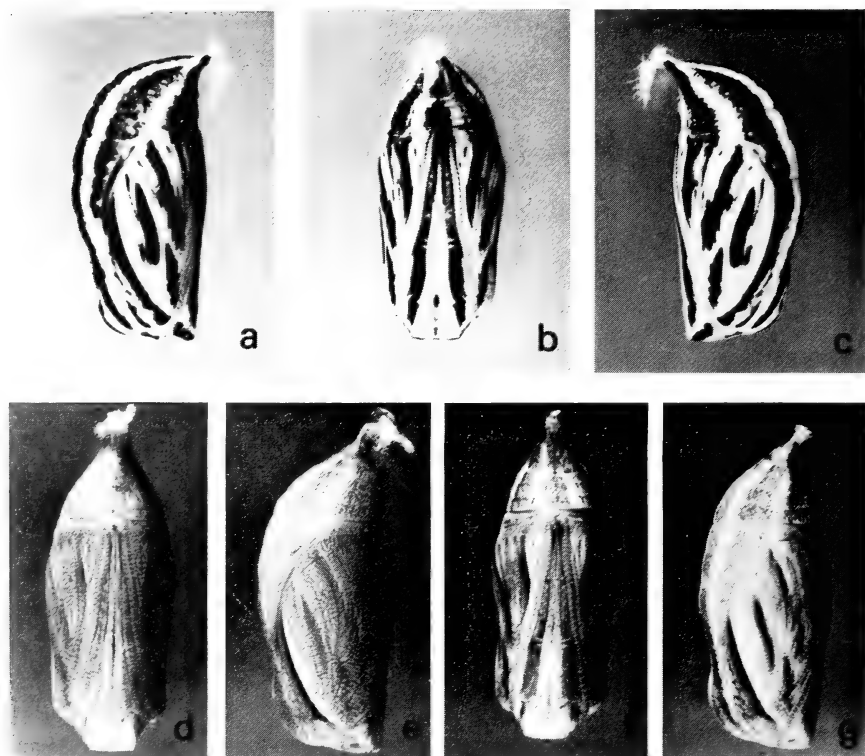


Fig. 11. Dorsal and ventral views of the three pupal color phases of *Cercyonis pegala blanca*: (a-c) black-and-white form (d-e) green form; (f-g) intermediate form.

terminally. Abdominal proleg crochets a uniordinal biserial lateroseries; crochets on anal proleg a uniordinal biserial penellipse opened caudally. Spiracles as in fourth instar except larger with raised projection smaller in proportion to diameter of peritreme. Caudal segment as in third instar except extreme posterior extremity of segment between forks adorned with small patch of purplish brown microspines.

**Fifth Instar. HEAD CAPSULE:** Average width, 3.21 mm; height, 3.35 mm (20 larvae). Ground color grass green (splitting along frontal suture with cast skin remaining attached, brown after ecdysis). Surface and setae as in fourth instar, except setae slightly longer, spiniform along dorsal cephalic margin. Chalazae large and bulbous, pearly white, sometimes becoming green basally. Most longer setae have bases expanded into a collar at attachment with chalazae. Mandibles with blackish brown color of cutting edge margin comprising one-third of mandible, central one-third cream colored, outer one-third translucent. Labrum translucent to cream colored distally, notch usually darkened. Bases of maxillary and labial palpi green, otherwise amber brown. Facial sutures heavily margined amber brown with brownish curved line connecting bases of in line ocelli. **TRUNK:** Average length, 33.2 mm (20 larvae; from 29.5 to 38.0 mm). Average width at first abdominal proleg segment, 1.65 mm. Ground color grass green modified by strongly defined segment annulations and frosted integument surface, and by pubescence of the predominantly spini-

form setae (barely discernible without magnification), to give trunk a whitish overcast, transversely ringed appearance. Chalazae greenish white and conical. Dorsal and lateral areas of trunk between longitudinal striping sometimes yellowish green, resulting from yellowish pigment spots under integument. Longitudinal striping as in fourth instar, except white of subdorsal and subspiracular stripes more pronounced. Abdominal prolegs as in fourth instar, except setae all long and spiniform arising from conical chalazae. Chalazae darkened distally along lateral aspects of legs. Crochets uniordinal and triserial (third row sometimes very limited). Anal proleg crochets form uniordinal triserial penellipse opened caudally. Spiracles all larger, transverse, and elliptical, otherwise as in fourth instar. Caudal segment setae on forks spiniform and a translucent rose color. Chalazae have distinct rose colored collar at juncture with setae. Amber brown microspines cover most of caudal extremity between forks.

**PUPA. GREEN FORM:** Entirely grass green, unmarked by any trace of black and white pattern. **BLACK AND WHITE FORM:** Pupal case totally marked by black and white longitudinal stripes. Around abdomen, striping evenly spaced and widest at thorax tapering to cremaster. The stripe located addorsally continued anteriorly adjacent to the dorsal meson white stripe terminating at the head. The subdorsal black stripe follows the dorsal margin of wing case to head, and the ventral meson black stripe divides at juncture of wing cases following the inner margin of antennae; they are nearly reconnected by a transverse black mark which crosses the head anterior to the crest of the eyes. Wing cases marked with irregular black dashes oriented obliquely to, and some appearing as extensions of, the longitudinal abdominal striping. **INTERMEDIATE FORMS:** Ground color of all pupae green. The extent to which black and white markings overlay the green highly variable, the green often being incompletely masked; thus all gradations of black, white, and green occur between the two extreme color forms. Black and white, however, modified simultaneously in that both tend to increase and decrease together. Occasionally, black pigment totally absent, exposing the green ground color which is still silhouetted by a remaining trace of white.

#### ACKNOWLEDGMENTS

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A NEW SUBSPECIES OF *LYCAEIDES ARGYROGNOMON*  
(LYCAENIDAE) FROM THE EASTERN CANADIAN FOREST ZONE

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It has been recognized for some time that the populations of *Lycaeides argyrognomon* from Southeast Manitoba, Ontario, Minnesota, Wisconsin and (probably) the upper peninsula of Michigan represent an undescribed subspecies distinct from *scudderi* (Edwards) with which they are usually allied. Griewisch (1953) collected long series of *L. argyrognomon* in Oconto and Marinette Counties, Wisconsin 1-15 July 1952, sent samples to Vladimir Nabokov at Harvard for determination, and quoted Nabokov's comments on them as follows:

"The Minnesota thing, which I described and figured, but did not name, because of scantiness of material (Bull. Mus. Comp. Zool., 1949, p. 505, Pl. 5, fig. 54, male, Pequot, Minn.) is a subspecies of *argyrognomon* (Bergstrasser, Tutt), which I now think is sufficiently distinct from the Canadian (north of 50°) *argyrognomon scudderi* (type loc.: The Pas, west of Winnipeg L., Manit.) to warrant a new subspecific name for it. It is this form that your specimens belong to, and you should be congratulated on establishing the interesting Wisconsin range of *argyrognomon*. It comes very near to a point where it should fly together with *melissa samuelis* Nab."

Griewisch later supplied a long Marinette County series of *L. argyrognomon* to Frank Chermock of Baltimore, Maryland. Chermock intended to describe these as an *argyrognomon* subspecies and distributed a number of them as "paratypes" bearing a manuscript name. Chermock and Griewisch are both deceased and for the last 20 years Nabokov has vacillated on doing further work with Lepidoptera. With no other heir apparent to carry on their work, I have assumed the responsibility, with this paper being the result.

The collections of Lepidoptera at my disposal probably contain more ample material in *Lycaeides argyrognomon* from the key areas of Manitoba, Minnesota and Wisconsin than any others. After an examination and study that has lasted three years, I find myself in full agreement with the earlier conclusions that the Eastern Canadian Forest Zone population of *Lycaeides argyrognomon* from southeast Manitoba, western Ontario, northeast Minnesota and northern Wisconsin is sufficiently distinct from *L. argyrognomon scudderi* to deserve its own subspecific name. I take pleasure in naming it in honor of Dr. Nabokov, who first recognized its

distinctness and whose papers on Nearctic *Lycaeides* (1943, 1944, 1949) have provided a background to make this description possible.

### ***Lycaeides argyrognomon nabokovi* J. Masters, new subspecies**

**Male** (Fig. 1): The same general appearance associated with all populations of *Lycaeides argyrognomon* but of a larger size and slightly more purplish color than any other. The expanse of one forewing (base to apex) 14 to 17 mm (average 16 mm).

**Upperside** (Fig. 1): Ground color of wings a vivid violet blue. Melanic margins (0.75 to 1.25 mm wide) not sharply defined on their basal margins. White fringes wide and well pronounced on fresh specimens. Darkened melanic spots, centered in the hindwing cells just basad of the melanic margin, present in some individuals. Scales along forewing veins darkened, especially limbally which gives the impression that their outer ends are swollen.

**Underside** (not figured): Markings essentially like the female, but with macules not as pronounced and with the orange and metallic elements not as vivid.

**Genitalia** (not figured): Typical of *L. argyrognomon*. Length of forearm of falx = 0.43 mm. Length of humerulus of falx = 0.32 mm. Length of uncus lobe = 0.33 mm. (Average values for three male paratypes dissected.)

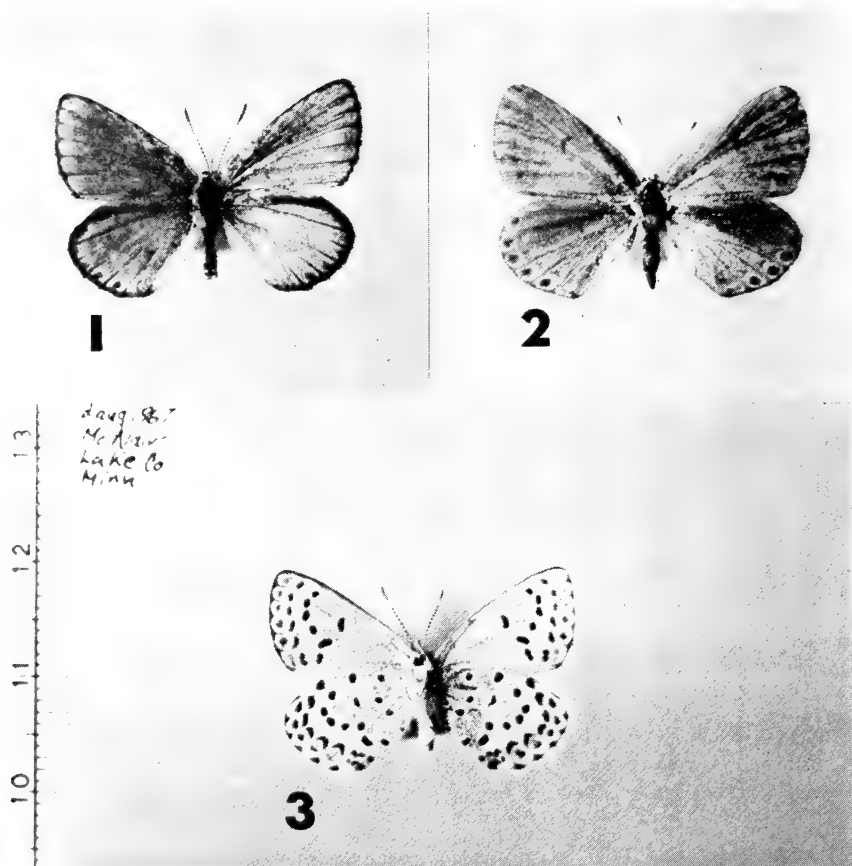
**Female** (Figs. 2, 3): Differs from male in being considerably more melanic on upper surfaces, confining the violet-blue coloration to the basal areas. The expanse of one forewing (base to apex) 14.5 to 17 mm (average 16 mm).

**Upperside** (Fig. 2): The purplish-blue coloration confined to the basal third of the forewing and the basal half of the hindwing. Remainder of the wings clouded with melanic scales that have little or no contrast with the borders. White fringes present on fresh specimens. On the hindwings, 4 to 7 oval melanic eye-spots present, centered in the cells near the outer margins, and these usually accompanied by an orange lunule basally. These macules especially prominent in cells  $CU_1$  and  $Cu_2$ .

**Underside of forewings** (Fig. 3): The ground color varies from a smoky grey to a bright white—tending to be lighter and whiter than in *L. argyrognomon scudderi*. A narrow melanic margin, thickened at the vein terminals, often extends around the apex to the costal margin. Two rows of submarginal spots, elongated or slightly crescent shaped, although never as dark or as well defined as the post-median spots. Submarginal spots often surrounded by a tint of orange. A row of six very well defined post-median spots, which vary greatly in shape but always baroque and non-uniform in appearance. Post-median macule in cell  $Cu_1$  always largest and conspicuous by its shape and position, being elongated and displaced basally. Post-median spots ringed in white, but contrast with the background color slight and effect not nearly so conspicuous as in *L. argyrognomon scudderi*. One additional macule on the forewing, a large oval or slightly crescent shaped spot at the end of the discal cell.

**Underside of hindwings** (Fig. 3): Ground color as on the forewings, with relatively little indication of the blue-green overcast that is usually conspicuous in the basal area with other subspecies of *L. argyrognomon*. Margin separated into triangular shaped spots at each vein terminus with only a thin line connecting them. Two rows of submarginal spots surrounded by an orange umbra which, on some specimens, coalesce into an orange band. Inner row characterized by a pronounced crescent shape while the outer row possesses metallic green centers basally, most pronounced in cells 2V,  $Cu_2$ ,  $Cu_1$  and  $M_3$ . A widely disjunct row of eight post-median macules, more regular in both shape and size than those on the forewing. Macule at the end of the discal cell crescent shaped and relatively thin and narrow. Three additional macules in the submedian area. All of the median macules ringed with white; however, hardly discernable on some specimens.

**Holotype male:** Along Forest Road 122 in section 24 of Township 56 N., Range 11 W., Lake County, Minnesota (16 July 1966), J. H. Masters, collector. Type



Figs. 1-3. *Lycaeides argyrognomon nabokovi* new subspecies: 1, male paratype, dorsal view; 2, female paratype, dorsal view; 3, female paratype, ventral view. All three specimens captured at "McNair," Lake County, Minnesota, 8 August 1967 by J. H. Masters. Approximately  $1\frac{1}{2}$  times natural size; millimeter scale at lower left.

locality 13 miles north of Two Harbors, near the former refueling stop of "McNair" on the DM & IR railway, now a part of The Superior National Forest. Expanse of forewing 16 mm. To be deposited in Carnegie Museum, Pittsburgh.

**Allotype female:** Same data as the holotype. Expanse of forewing 16 mm. To be deposited in Carnegie Museum, Pittsburgh.

**Paratypes:** 58 males, 34 females, same locality as holotype, various dates, July and August 1966, 1967, 1968 and 1970, J. H. Masters and William A. Bergman collectors. Paratypes will be deposited in the collections of the United States National Museum, American Museum of Natural History, Los Angeles County Museum, Museum of Comparative Anatomy at Harvard, Manitoba Museum of Man and Nature, and University of Minnesota. The remainder will, for the present, remain in the author's and W. A. Bergman's private collections.

**Other localities:** Paratypes were restricted to specimens from the type locality.



Other populations that I consider belonging to this subspecies include specimens from the following localities: **Minnesota:** Echo Trail, near Ely, Saint Louis County; Gunflint Trail, T.64 N., R.1 W., Cook County; near Pengilly, Itasca County; vic. Pequot Lakes, Crow Wing County. **Wisconsin:** near Crivitz, Marinette County; Wambee Lake Area, Oconto County. **Manitoba:** White Shell Provincial Park; Wanipigow River, near Bissett. **Ontario:** The following localities are cited by Riotte (1971) for *Lycaeides argyrognomon*; Armstrong, Favourable Lake, Minaki and Nakina; all of which undoubtedly represent this subspecies.

*Lycaeides argyrognomon nabokovi* is one of eleven Nearctic subspecies which include *anna* (Edwards), *ricei* (Cross), *lotis* (Lintner), *alaskensis* (Chermock), *scudderi* (Edwards), *aster* (Edwards), *ferniensis* (Chermock), *atrabraetextus* (Field), *sublivens* Nabokov, and *longinus* Nabokov. Descriptions and distributional data for all of these can be found in Nabokov (1949). DosPassos (1964) also includes *kodiak* (Edwards) and *empetri* (Freeman) as subspecies under *argyrognomon*. Nabokov considered *kodiak* as a taxa of uncertain status, probably not belonging to *Lycaeides*; Brown (1970) considered it as a subspecies of *Plebejus saepiolus*. Nabokov considered *empetri* (type locality Cape Breton Island) to be a synonym of *aster*.

In the past, populations of both *Lycaeides argyrognomon nabokovi* and *Lycaeides melissa samuelis* have been confused with *L. scudderi*. The specimens figured by Holland (1931, plate XXX, figs. 48, 49) as *scudderi* are actually *samuelis*. *Lycaeides argyrognomon scudderi* (type locality "between Lake Winnipeg and Cumberland House," Manitoba; Brown, 1970) is now restricted to regions west and north of Lake Winnipeg—it occurs as far south as Riding Mountain. The barrier between *scudderi* and *nabokovi* is Lake Winnipeg and the Red River Valley (the area formerly occupied by glacial Lake Agassiz), which suggests that the two subspecies have been isolated since late in the Pleistocene. Since *nabokovi* is more likely to be confused with *scudderi* than with any other subspecies in the future, it seems pertinent to summarize the differences between the two:

Ground color of ventral surfaces tends to be lighter and whiter in *nabokovi*, which renders the white rings, circling the post-median macules, less distinct. Basal blue-green dusting on ventral hindwing is much less evident on *nabokovi*. The post-median macules on the ventral forewing of *nabokovi* are larger and much more irregular in shape and position than they are in the case of *scudderi*. In the case of *scudderi*, they form an almost uniform row of almost equal-sized spots. The elongated and distorted macule in cell Cu<sub>1</sub> is usually diagnostic of *nabokovi*; in the case of *scudderi*, this macule is much more rounded and regular in appearance. This specimen selected by Brown (1970) as the neotype for *Lycaena scudderi* is an exception to this, having the

macule in Cu<sub>1</sub> elongated very much like *nabokovi*. I have not noted this condition, however, in 30 specimens of *scudderi* that I have examined from Riding Mountain, Duck Mountain and The Pas, Manitoba.

The *Lycaeides argyrognomon aster/empetri* populations, with which *nabokovi* more than likely intergrades at some point, occur in Newfoundland, Nova Scotia, Labrador, Cape Breton Island and northeastern Quebec. Brown (1970) confines *aster* to the Avalon Peninsula of Quebec and relegates populations from other parts of this region to *empetri*. The combined *aster/empetri* populations are small and pale with small, round and well separated macules in the post-median series. The post-median macules are the same size or smaller than the marginal macules, whereas in the case of *nabokovi* they are significantly larger. The *aster/empetri* populations are characterized by considerable blue-green dusting basally on the ventral hindwings, and by very little blue coloration dorsally in the female. There is a probable zone of intergradation between these two forms in eastern Ontario or Quebec.

The only species occurring in the same regions with *nabokovi*, with which it might be confused, is *Lycaeides melissa samuelis*. These two cannot be considered as sympatric, however, as *nabokovi* is confined to Canadian Zone forests while *samuelis* is confined to open prairie regions. The ventral wing margin in *Lycaeides melissa* has a narrow but solid and straight terminal line; while in *Lycaeides argyrognomon*, this line is usually broken into triangular shaped spots at the vein terminals. If this fails to provide a definitive separation of the two species, dissection of the male genitalia will. In *L. melissa* the length of the forearm of the falx is twice as long as the length of the humerus of the falx while in *L. argyrognomon* it is but one and a half times as long.

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# THE ECOLOGY AND ETHOLOGY OF THE TROPICAL NYMPHALINE BUTTERFLY, *VICTORINA EPAPHUS*.

## I. LIFE CYCLE AND NATURAL HISTORY

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This paper is the first in a series on the neotropical butterfly, *Victorina* (*Amphirene*) *epaphus* Latreille in central Costa Rica. Despite its widespread occurrence throughout the montane and upper premontane tropical wet forests of Costa Rica, little is known about its biology. According to Seitz (1924) the life cycle of this Central American species is undescribed. This paper describes the life cycle of this species, and brings together various observations on its ecology and ethology, to be explored in depth in later papers. Data on larval host plant specificity, oviposition, and survival of immatures in natural populations also are given.

### METHODS

*V. epaphus* was studied at Cuesta Angel de Sarapiquí (Heredia Province, 1000 m elev.) at various times from February 1969 through July 1970. Observations were made at the bottom of a steep ravine, in relatively undisturbed, primary-growth forest. The study of *V. epaphus* consisted of three approaches: larval host plant studies, field studies, and laboratory studies.

### Larval Host Plant Studies

The study site is near an extensive strip of the larval host plant, *Ruellia tubiflora* H.B.K. var. *tetrastichantha* (Lindau) Leonard (*Acanthaceae*) which borders the Rio Sarapiquí and a foot trail at the bottom of the ravine. This plant, (a first record for *V. epaphus*) is an understory form, usually between 15–40 inches in height, and confined to very wet soil. At Cuesta Angel, it grows in continuous patches along with *Gynandropsis pulcherrinia* Standl. (*Capparidaceae*), another understory plant of similar height and growth form, which is a major larval host plant of *Itaballia caesia* (Pierinae), whose life cycle will be summarized later. Unlike the spatial distribution of larval host plants of tropical butterflies belonging to the genera *Morpho* (Young, in prep.), *Parides* and *Battus* (Young, 1972a, b, c), the larval host plant of *V. epaphus* is characterized by rather extensive homogeneous patches, permitting a concentration of reproductive effort (Labine, 1968) over small portions of the habitat.

The larval host plant of *V. epaphus* was in active vegetative growth during the study period and floral structures were absent despite the low degree of seasonality known for montane tropical wet forests (Richards, 1952; Roth & Bifano, 1971). Extensive searching revealed that it is the only host plant of this butterfly at Cuesta Angel.

### Field Studies

Field studies consisted of (1) mark-recapture studies on adults, (2) analysis of diurnal peak activity periods of adults, (3) observations on oviposition behavior, (4) records on the distribution of eggs and larvae on individuals of the host plant, including observations on larval activities, and (5) occasional records of predation and parasitism on larvae.

Mark-recapture study employed a standard sampling procedure in which adults were netted on several traversions through the host plant patch, marked, and immediately released. This was done at irregular intervals throughout the study period, using a marking system modified from Ehrlich & Davidson (1960) and in which sexes were differentiated. Estimations of adult populations then were made for each day of observation, using the Lincoln Index. Eggs, larvae, and pupae also were sampled in a standardized manner by walking transects through the patch once daily. Individual host plants along the transect were examined frequently for eggs and larvae. This sampling technique was very suitable since the host plant grew in large homogeneous patches, allowing many individuals to be sampled quickly.

### Laboratory Studies

Broods of eggs were reared, both in the laboratory and out of doors. Life stages and developmental time were studied in this manner. Laboratory cultures were established in tightly closed 8 in by 12 in clear plastic bags, prior to each of these receiving several eggs on cuttings of *Ruellia*. This method has proven successful with several species of tropical butterflies (Young, 1972a, b, c, d, e). Various aspects of larval behavior were also noted, such as diurnal pattern of peak feeding, gregariousness, and aggressiveness. Laboratory rearing was undertaken to explore also the feasibility of using this widespread species for estimation of physiological life tables (Istock, 1970; Young, 1972e) to be eventually compared with realized life tables of natural populations. Other interests focused upon the suitability of such a widespread tropical species for electrophoretic studies of enzyme variability as a function of geographic and topographic distributions of populations.

## RESULTS

## Description of Life Cycle

The eggs are laid singly in small, loose clusters on apical, unfolding leafbuds of *Ruellia* (Fig. 1,A), and occasionally on older leaves. Anywhere from 1-6 of the dorso-ventrally flattened (diameter of 0.9 mm) ribbed eggs are laid by an individual female during one visit to a plant. When first deposited, each egg is pale green but rapidly (10-15 min.) becomes dark green between the yellowish ribs (Fig. 1,A). Eggs are placed carefully on leaves of *Ruellia* and "errors" in oviposition (Dethier, 1959a, b) have not been seen.

The first-instar larva devours its empty egg shell. The young larva then moves to the ventral side of an apical, unfolding leaf to begin feeding. The first-instar larva is jet black except for the first segment behind the head, and the two most posterior segments, which are a dull-orange color. The head is shiny jet black, bearing two long slightly barbed spines; shorter branched spines are present on all other body segments. With the exception of the single pair of head spines, all remaining spines are ringed with white at their bases. Each body segment, excluding the first behind the head, bears three pairs of these spines. The second-instar larva is about 7 mm long. The third instar is similar (Fig. 1,C) and about 16 mm long when molting to the fourth instar.

A drastic change in appearance occurs in the fourth instar. The larva is now between 29-35 mm long and the head is still shiny jet black, but the body is velvety maroon. The head spines are still long. All other spines are now bright yellow and more highly-branched (Fig. 1,D). The bases of all body spines are bright yellow. The final, fifth-instar larva (Fig. 1,E) is almost identical to the fourth instar except that the head spines and the most lateral pair of spines along the body axis are red. The expanded basal spots no longer are associated with each spine. Of the three pairs of spines on each body segment present in all five instars, only the most dorsal pair remains bright yellow; the next pair has the lower half a dull yellow and the upper half light orange; the third, most lateral pair of spines are entirely red. All spines remain very highly branched. The mature larva is between 45-55 mm in length.

Pupation typically occurs on the undersides of older leaves near the ground. The pupa (Fig. 1,F) is about 30 mm long, and pale, translucent green, although flecked with tiny black spots arranged in longitudinal rows on the thorax and abdomen. There are two prominent orange-based black spines originating dorsally from the first and second abdominal segments. The head region is slightly forked anteriorly, with projections being green below and black above.

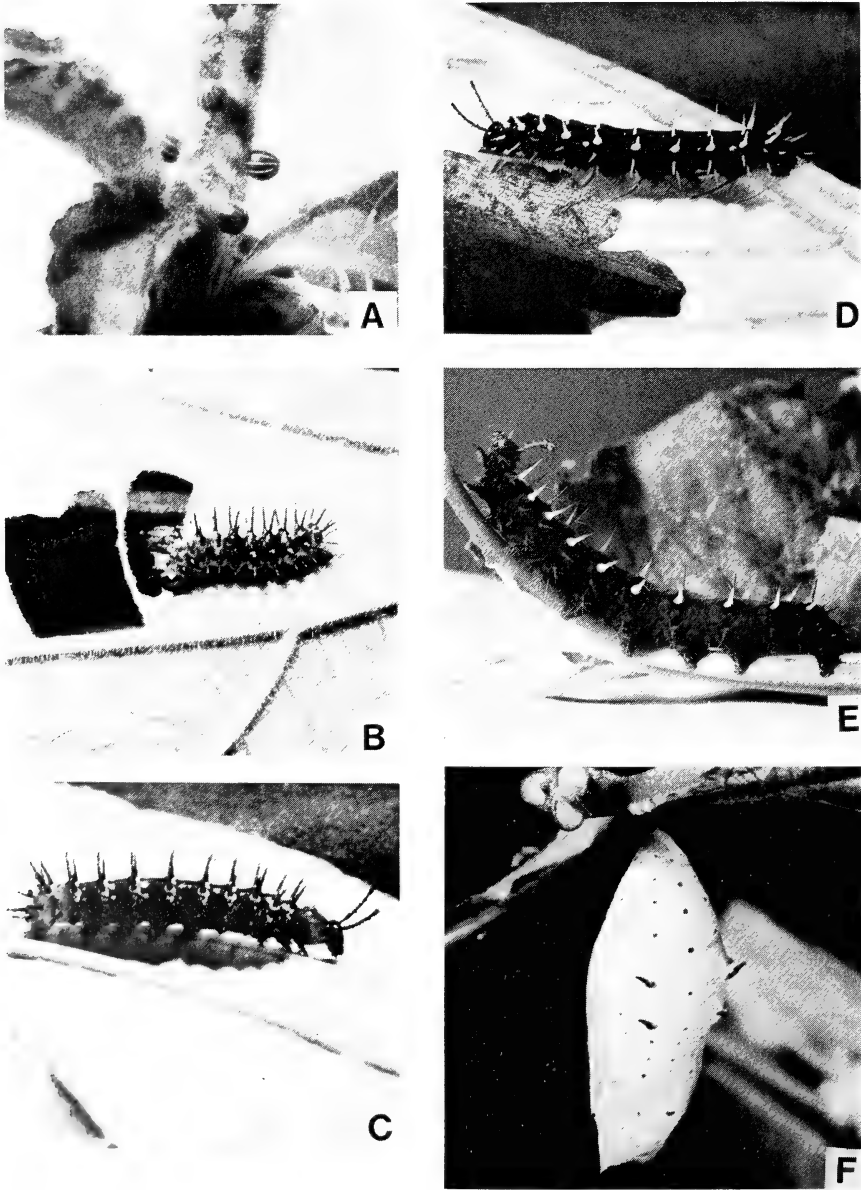


Fig. 1. Life cycle of *Victorina epaphus*: (A) eggs, (B) second instar, (C) third instar, (D) fourth instar, (E) fifth instar, and (F) pupa.



Fig. 2. Adult *Victorina epaphus*. Dorsal views of female (above) and male (below). Mean wingspan length is  $7.0 \pm 3.8$  cm ( $N = 34$ ) with females slightly larger than males.

A lack of sexual dimorphism characterizes the adults of *V. epaphus* (Fig. 2). However, the female generally is larger than the male (by 3–6 mm) and the cream-colored band separating distal orange areas and proximal brown areas of both wings is broader. It is very difficult to distinguish sexes in the field.

The developmental time for *V. epaphus* (summarized in Table 1), is slightly more than one month. Data on survivorship of larvae and pupae in the laboratory indicate that this insect can be reared successfully under artificial conditions (Table 1).

Development within egg clusters is highly synchronous, in the field and laboratory, with virtually no individuals completing postembryonic development markedly later than other individuals. Breeding is continuous throughout the year.

TABLE 1. The developmental time (days) for *Victorina epaphus* under laboratory conditions.\*

	Egg	Instar 1	Instar 2	Instar 3	Instar 4	Instar 5	Pupa	Total
Mean	6.85	4.97	5.05	4.14	2.20	2.15	10.35	35.71
S.E.	±.10	±.11	±.08	±0.9	±.10	±.04	±.25	±1.24
Range	6-9	4-6	4-7	3-6	2-5	2-4	9-11	32-38
No. of Individuals	57	54	54	54	51	48	48	48
No. which Died	0	3	0	0	3	3	0	9

\* Times estimated from a total of 57 eggs, representing 10 clusters deposited on 10 individual foodplants by a single female within an 18 minute period (1440-1458, CST) on 29 Jan. 1970 near Cuesta Angel, Heredia Province. All cultures were kept in large (8 × 12 in.) clear plastic bags in one large room in San Jose, Costa Rica. Eggs were collected at Cuesta Angel immediately following oviposition and brought directly to San Jose for culture.

### Population Size and Mortality

Estimations of adult population sizes are summarized in Table 2 along with frequencies of immature stages. A striking result of this survey is that both egg and adult numbers remain constant throughout the year despite fluctuations in numbers of larvae and pupae.

Survivorship from egg through pupa in the field high (Table 3). Predation and parasitism on eggs and larvae are probably low. However, the large fluctuations in larval numbers and the diminished numbers of pupae (Table 2) suggest operation of undetected mortality factors. I have consistently failed to rear tachinid or braconid parasites from larvae collected in the field.

TABLE 2. Weekly frequencies of adults and immature stages of *Victorina epaphus* at Cuesta Angel, Heredia Province, Costa Rica from early February through early April, 1969.

Stages	Number of Individuals Seen Per Week								
	Feb. 3	Feb. 10	Feb. 17	Feb. 24	Mar. 10	Mar. 17	Mar. 24	Mar. 31	Apr. 7
Adults	44	40	43	26	38	59	63	44	49
Eggs	134	168	159	103	97	107	115	78	133
Larvae	109	115	123	73	68	89	100	52	102
Pupae	22	18	20	7	20	31	18	9	23
Total	309	341	345	209	223	286	296	183	307

Adult figures are based on capture-mark-recapture estimates. No observations were made during the week of March 3.



TABLE 3. A summary of some measurements of population parameters of the tropical nymphalid, *Victorina epaphus*.\*

Egg Cluster No.	No. of eggs per cluster	No. eggs killed by predation	No. eggs failing to hatch	Larval mortality	Pupal mortality	Overall % survivorship
1	7	5	0	1	0	13.8%
2	5	3	0	0	0	40.0%
3	8	4	0	1	1	25.0%
4	6	0	0	3	0	50.0%
5	6	0	0	2	0	20.0%
6	5	2	0	2	0	20.0%
7	7	2	0	3	0	29.0%
8	8	0	1	5	1	12.5%
9	10	1	0	6	0	30.0%
10	4	4	—	—	0	0.0%
11	6	0	1	3	0	33.4%
12	5	0	0	2	0	60.0%
13	7	3	0	3	1	0.0%
14	6	2	0	2	0	33.4%
15	6	2	0	1	1	33.4%
16	5	2	0	1	0	40.0%
17	5	2	0	2	0	20.0%
18	8	1	0	3	1	37.5%
19	6	0	1	2	0	50.0%
20	5	0	0	2	1	40.0%
21	7	3	0	3	1	0.0%
22	7	0	0	2	0	71.4%
23	5	2	0	1	0	40.0%
24	8	2	0	2	0	50.0%
25	6	1	0	2	0	50.0%
26	6	0	0	2	0	66.7%

\* These measurements were made in the field on immatures staked out on various individual foodplants within a large rectangular area of forest understory.

### Larval Behavior

Larvae, although diurnal feeders, are difficult to detect in heavily shaded forest understory. These observations suggest that *V. epaphus* is a palatable species which employs a protective strategy of crypsis while going through ontogeny. Some genera of Acanthaceae contain alkaloids and may be toxic (Irvine, 1961), but it remains unknown whether species of the genus *Ruellia* are toxic. While predation on adults by birds and lizards in the field has not been observed, laboratory feeding studies of a related species, *V. steneles*, indicate non-toxicity (Brower & Brower, 1964). But in Costa Rica, larvae of this latter butterfly feed on *Justicia* in the Acanthaceae (Young, 1972e). They invariably feed from the ventral leaf surface and are therefore usually concealed from potential predators foraging from above. Presumably in the dark forest understory, the larvae would be difficult to detect by predators on the ground. Such larval

behavior may also lower parasitic attack by hymenopterans and tachinids which lay their eggs directly upon the host.

Larvae are capable of violent jerking movements of the anterior region of the body, presumably as a means of defense against predators. However, they do not exhibit these movements collectively, as noted for larval sawflies (Prop, 1959). The pupae of *V. epaphus* are also capable of similar movements, possibly a means of deterring parasitic wasps and flies (Cole, 1959). The numerous spines on all instars and to a lesser extent on pupae, coupled with violent jerking movements, may provide an effective predator-parasite deterring mechanism.

Larvae are never gregarious, despite eggs being laid in loose clusters. Immediately following devouring of empty egg shells, larvae disperse and never reassociate during ontogeny. Crowded larvae in the laboratory are aggressive towards one another. Such behavior may permit effective dispersion on host plants. However, larvae never leave an individual plant to feed on another one nearby. This is true despite the fact that *Ruella* grows in large patches of high density on the forest floor. Apparently larval densities per individual host plant never reach levels at which overcrowding and aggressiveness result in dispersion from the plant.

### Adult Behavior

Adults of *V. epaphus* restrict their flying activities to *Ruella* patches. Here the sex ratio remains close to unity, although adult numbers are low (Table 2).

Presumably courtship occurs near host plant patches and females are mated within 5 days after eclosion. Of 38 young females examined, only 3 contained more than one spermatophore.

Oviposition generally takes place throughout the day and each female performs several oviposition sequences on any given day. Observations on young marked females indicate that each individual conducts up to 11 oviposition sequences within a single *Ruella* patch before resting. Resting periods between groups of oviposition sequences are brief. Each female deposits a mean number of  $5 \pm 1.4$  eggs per plant.

Adults sometimes feed collectively in small numbers at moldy leaf litter on the forest floor, although they probably also forage at flowers. At Bajo la Hondura, this species has been observed to feed at odorous small growths of fungi on tree trunks. Collective feeding in this species is not structured and individual feeding also prevails. Feeding appears to be most frequent during the morning hours.

Adults are not commonly encountered in second-growth plant communities, but appear restricted to primary-growth montane forests. Adults

fly low, seldom higher than 10 feet off the ground. It therefore is a montane forest species concentrating reproductive and feeding activities, as well as general flight activity, to understory habitats.

#### DISCUSSION

The above notes on the biology of *V. epaphus* may best be integrated through consideration of an adaptive strategy for inhabiting understory regions of primary-growth forests. Several discussions (Pires, Dobzhansky, & Black, 1953; Slobodkin, 1970) have emphasized the structural complexity and stability of primary-growth tropical rain forests. Component species of such habitats are predicted to have a long evolutionary history integrating them into communities (e.g. MacArthur, 1969). The adaptations of *V. epaphus* to the forest understory environment will therefore be emphasized in this discussion.

The strategy of ecological adaptation in a butterfly is molded by the spatial distribution and numerical abundance of the host plant (Singer, 1971). Given the patchy distribution of *Ruella* in montane wet forest understory and the relatively large size (high and numerical abundance) of individual host plant patches, some predictions about the ecological traits of *V. epaphus* (and other herbivores of *Ruella*) can be formulated.

*V. epaphus* can be described as a non-seasonal breeder with reproduction occurring throughout the year. Ecological studies of tropical butterflies should focus upon the major adaptations of life cycle to seasonal contractions or expansions in the amount of larval host plant (i.e., by seasonal differences in vegetative growth rates) in a given type of plant community, and at different altitudes. For example, *V. epaphus* is predicted to be a non-seasonal breeder since it is an understory species. It has been stressed by botanists (e.g. Webb et al., 1967) that the understory component(s) of primary-growth tropical forests provides a buffered environment for many organisms, protecting them from the major local vagaries of climate experienced by the canopy.

The understory represents a non-seasonal environment, and species of butterflies which breed there may possess non-seasonal patterns of reproduction. The strategy is in part a function of host plant selection in the understory community, and discrimination of young vegetative growth zones (unfolding leaf buds or apical meristems) for oviposition. Also, first-instar larvae may be physiologically and morphologically adjusted for feeding only on the youngest leaf tissues, in response to both physical (leaf shape, thickness, toughness) and chemical (quantitative and/or qualitative differences in secondary compounds involved in gustatory cues) properties of the leaves. Tropical butterflies may therefore fall

into three major classes of breeders: wet season breeders, dry season breeders, or non-seasonal breeders. The more seasonal breeders are predicted for typically second-growth species, although understory habitats cannot be excluded entirely, especially for tropical dry forests.

Oviposition should be very precise in *V. epaphus*, if selection pressures are favoring the evolution of very specialized behavior patterns (Margalef, 1968). Errors in oviposition are predicted in species having high fecundities and colonizing episodes, a good example being the second-growth butterfly, *Anartia fatima* (Nymphalinae) (Young, 1972e). Understory species such as *V. epaphus* concentrate the bulk of their reproductive effort (Labine, 1968) over a relatively small portion of the available habitat containing substantial numbers of the larval host plant. Adult vagility, under such conditions, would be low. At least one temperate zone species of pierid associated with second-growth plant communities experiences density-related dispersal of gravid females, presumably in response to increase in local adult population density (Shapiro, 1970). High adult vagility has also been measured in a second-growth satyrid (Brussard & Ehrlich, 1970).

On the other hand, studies of *Euphydryas editha* (Ehrlich, 1961) indicate low vagility. In tropical forest understory, butterflies may be less prone to dispersal due to reduced visibility resulting from shading and dense foliage. But comparisons of adult numbers with numbers of pupae (Table 2) suggest some adult dispersal, assuming negligible mortality. Nevertheless, a high proportion of individuals remain residential at the host plant. Such behavior gives breeding a patchy distribution, corresponding to the distribution of host plant patches (although not all host plant patches need be colonized by *V. epaphus*). Both factors, in conjunction with either low fecundity or high mortality of immatures, prevents over-exploitation and local extinctions of populations of *V. epaphus*.

Oviposition on tiny unfolding leaf buds may lower rates of predation or parasitism upon eggs. Eggs are partially concealed from wandering predators such as ants and aerial forms such as predatory Hemiptera. The unfolding leaves of *Ruella* appear much lighter in color than older leaves to the human observer. It has been demonstrated under laboratory conditions for various butterflies, that ovipositing females are capable of discriminating shades of green, corresponding roughly to age differences in coloration of leaves seen in host plants (Ilse, 1941; Vaidya, 1969). A similar discriminatory mechanism presumably occurs in *V. epaphus*, since the majority of eggs are deposited on the very young leaves of *Ruella*. A major selective force favoring such discrimination may be site selec-

tion for oviposition where eggs are least likely to be detected. Certainly increased ease of feeding for first-instar larvae on tender leaf tissue may also be an important factor (Thorsteinson, 1960).

The marked variability in time of oviposition is attributed to persistent cloud cover over these regions for a substantial portion of each day. Persistent cloud cover is a major feature of montane tropical forests (Myers, 1969; Roth & Bifano, 1971) and plays an important role in the adaptation of various organisms to these habitats. Oviposition in understory butterflies occurs over a wide range of hours since light remains at low intensity throughout the day. Thus, potential predators of ovipositing females such as understory birds would experience equal difficulty all day long in detecting their prey. There would be no hindrance to the ovipositing butterflies since they rely mainly upon olfactory and not visual cues in locating host plants.

In lowland tropical forests, oviposition is predicted to occur during moments of prolonged cloud cover (which usually takes place during the afternoon) since potential predators would be less of a threat during periods of reduced and diffused light. Oviposition in such species that have experienced a long evolutionary history involving adaptation to living in understory, should be lowest during the morning hours, when bright sunlight can filter down through the canopy. Such an oviposition pattern has been observed in *Victorina steneles*, a butterfly which is very common in tropical wet lowlands (Young, 1972e).

The forest understory also provides a suitable habitat for the exploitation of crypsis as an adaptive strategy for larvae. Not only does shade reduce the hunting success of visual predators, but the feeding positions of larvae on the host plant also contribute to protection. Older larvae generally feed ventrally along the edges of leaves; they adopt feeding positions that apparently optimize food intake per unit time as their positions fit very well recent predictions concerning such behavior (Heinrich, 1971). This results from progressive movement of larvae down the plant as they grow larger; older larvae invariably feed on the lowest (generally oldest) leaves. The adaptive significance of this behavior is clear: larvae, as they get bigger, are able to take in more plant tissue per unit time and are less exposed to potential predators while feeding. Selection may favor the evolution of such behavior in a palatable species since it helps to maximize escape from predators which forage from above. This hypothesis, however, remains to be confirmed.

If further study reveals that the realized life table ("realized fitness"—Istock, 1970) approaches the physiological life table ("physiological fitness") for *V. epaphus* (Young, 1972e), then the idea that species well-

integrated into stable tropical communities possess very specialized and efficient defense mechanisms against predators, pathogens, and parasites would be confirmed (Margalef, 1968; Pianka, 1966). Adult survivorship in natural populations of *V. epaphus* is generally high (Young, 1972e), although the reasons for this are not known. A related species, *V. steneles*, enjoys high adult survivorship both in Batesian mimetic association with the heliconiine, *Philaethria dido* (Brower & Brower, 1964) and even when not in mimetic association (Young, 1972d). Recent studies of second-growth species of Costa Rican butterflies (Young, 1972a; Young & Muysshondt, in prep.) reveal high rates of parasitism on eggs and larvae during selected times of the year. High levels of biotic mortality, if persistent, suggest lack of integration of herbivorous species into second-growth communities.

The depression in adult numbers during February–April (Table 2) may indicate decreased availability of adult food sources associated with diminished rainfall during this period. Cuesta Angel experiences a short and erratic dry season (“veranillo”). Reduction in monthly precipitation may destroy some food sources, such as fermenting patches of fungi on trees, or even flowers. During the wetter months, some adults may be killed off by heavy rains, although this is apparently constant (Table 2), and not highest at the beginning of the wet season, as observed for *Parides* (Papilionidae) on Trinidad (Cook, Frank & Brower, 1971). Such an adult mortality factor would be very sensitive to local topographical and climatological features, varying greatly at different localities, especially along altitudinal gradients (Holdridge, 1967).

The narrow local host plant specificity of larval *V. epaphus* is interesting. Although there have been discussions of mutualistic effects among plants and their lepidopterous herbivores (Ehrlich & Raven, 1965), relatively few studies have dealt with local host plant specificities at the species and generic levels, with the notable exception of some temperate zone lycaenids (e.g., Downey & Fuller, 1961; Downey & Dunn, 1964), *Papilio glaucus* (Brower, 1958), and *Euphydryas editha* (Singer, 1971). The single host plant of *V. epaphus* at Cuesta Angel is probably the only one that this butterfly exploits in this region of Costa Rica. At Bajo la Hondura, a montane region located on the Pacific slopes of the Cordillera, but of the same forest type and elevation as Cuesta Angel on the Atlantic slopes, *V. epaphus* exploits a different host plant, *Hygrophila guianensis* Nees (Acanthaceae). Like *Ruellia tubiflora* at Cuesta Angel, this plant is characteristic of river edges at a wide range of elevations throughout Central America (D. C. Wasshausen, pers. comms.). But *Ruellia* is not found at Bajo la Hondura nor is *Hygrophila* found at Cuesta Angel. It

would be interesting to determine whether two distinct strains (or sibling species) of *V. epaphus* have evolved in Costa Rica, in response to differences in levels of host plant toxicity between the two localities (Cuesta Angel and Bajo la Hondura). Clearly experimental feeding studies are needed to demonstrate differences in palatability between the two populations. Brower & Brower (1964) found that adults of *V. steneles* are palatable although various members of the Acanthaceae are known to contain alkaloids (Arthur, 1954; Irvine, 1961). Levels of toxicity for either *Ruellia* or *Hygrophila* are not known.

A case of allopatry between *V. epaphus* and *V. steneles* may exist in Costa Rica. *V. steneles* is common throughout the Caribbean and Pacific lowlands (10–100 m elev.) of Costa Rica, where its major larval host plants, various species of *Justicia* in the Acanthaceae (Young, 1972e), are located. Here *V. epaphus* is generally absent, with the lowest elevations of its distribution being the Meseta Central (San Jose Province) between 200–500 m. However both species successfully complete development on the other's host plants in the laboratory. Therefore, other environmental factors, such as physiological adjustments to temperature and ecological barriers associated with topography may be important in determining altitudinal ranges of both species (Janzen, 1967). In the lowlands, *V. steneles* enjoys high adult survival as an understory species of primary-growth forest (Young, 1972d, e), where it represents a major zoogeographical expansion of the genus *Victorina* at low elevations. At higher elevations, a similar major adaptive radiation is portrayed by *V. epaphus*. The distribution of these species along altitudinal gradients varies greatly in different regions of Central America. In El Salvador, *V. steneles* occurs at elevations up to about 600 m, and *V. epaphus* is found at higher elevations (Young & Muysshondt, in prep.).

#### SUMMARY AND CONCLUSIONS

(1) The life cycle of *V. epaphus* is described for the first time, and data on developmental time are given.

(2) *V. epaphus* is an understory species of montane tropical wet forests, where it exploits localized patches of its larval host plant.

(3) Larval host plant specificity in *V. epaphus* is very high on a local basis, although different host plants are exploited in different parts of its extensive geographical range along the Cordillera in Costa Rica. At Cuesta Angel, a locality along the Atlantic (Caribbean) slopes, the host plant is *Ruellia tubiflora*, while at Bajo la Hondura, a locality of similar elevation and forest-type on the Pacific slopes, the host plant is *Hygrophila guianensis*. Both plants are in the Acanthaceae.

(4) Immatures and adults of *V. epaphus* have high survival rates. Predation and parasitism are low. Such life table characteristics are correlated with low fecundity, low adult vagility, and cryptic behavior patterns of larvae.

(5) The genus *Victorina* in Central America seems to have undergone allopatric speciation, splitting into two species, *V. epaphus* and *V. steneles*, along altitudinal gradients. The former species is characteristic of montane forests and plateaus, while the latter species is more characteristic of the lowlands. However, larvae of both species can complete development successfully on the other's host plants.

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## PIERIS NAPI L. (PIERIDAE) AND THE SUPERSPECIES CONCEPT

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This is a subject to be treated at greater length on some future occasion: the present note is intended to draw attention to unresolved taxonomic questions, which particularly affect the North American populations.

When the European collector enquires, "Is *bryoniae* Ochseneimer a separate species?" he may mean either of two different things. He may be asking whether ssp. *bryoniae* is reproductively separate from the other *Pieris napi* L. flying in the same country, or he may want to know whether *bryoniae* + *flavescens* Wagner + *neobryoniae* Sheljuzhko and perhaps *adalwinda* Fruhstorfer + *hulda* Edwards + . . . . . are reproductively isolated, severally, from *napi* + *britannica* Verity + *meridionalis* Heyne + *oleracea* Harris + *venosa* Scudder + . . . . The answers are likely to be different, and only that to the simpler question can be unequivocal.

Dobzhansky (1970), quoting Mayr and also Amadon, defines a super-species as a monophyletic group of closely related and largely or entirely allopatric species, or as a group of . . . . essentially allopatric taxa that were once races of a single species but which have now achieved specific status. The components of the superspecies are semispecies or allospecies; gene-exchange is still possible among semispecies but not as freely as among conspecific populations. Thus the Holarctic *Pieris napi-bryoniae* complex is a perfect example of a superspecies.

The definition involves "species," which can itself be defined in many different ways. For butterflies, a formally new, though quite theoretical, criterion of species status has been given (Bowden, 1972):

Where the taxa have come into contact, if sympatry is leading to increased genetic and sexual barriers between them, the populations are to be taken as already belonging to distinct species; if not, not.

This fixes speciation at a rather earlier stage than the "full speciation" of many systematists, and transfers a number of supposed semispecies to the

species category. But of course it still gives no assistance with populations which have remained apart geographically, except in so far as captive pairings provide evidence of the probable results of cross-breeding in the wild.

The usual tests decide readily enough that *Pieris virginiensis* Edwards is specifically separated from *P. napi oleracea*, and experiments (Bowden, 1966, 1972) leave no doubt that it is also distinct from *P. n. napi*.

We can be nearly as certain that, in Switzerland, wild *bryoniae* is reproductively almost completely isolated from *napi*, though fertile hybrids are easily obtained in captivity. Experimentally, fertile *oleracea*  $\times$  *bryoniae* F<sub>1</sub> pairings are obtained as easily as *napi*  $\times$  *bryoniae*, but thereafter fertility crashes (Bowden, 1972). On the other hand *oleracea*  $\times$  *napi* can be carried to the direct F<sub>3</sub> at least. These results permit the conclusion that *P. n. napi* and *P. n. oleracea* are still conspecific, and will interbreed if the Atlantic Ocean is abolished next year. But it is not necessary to wait so long to conclude that reproductive barriers would in fact go up rapidly—*oleracea* and European *napi* are very different insects.

The writer has appreciable breeding experience of only three Nearctic subspecies of *napi*, including *virginiensis*, the third being *marginalis* Scudder. None of these can be raised on *Alliaria*, a plant which the European subspecies eat readily (Bowden, 1971a, 1971c). The larvae all differ from European *napi* and *bryoniae*, most conspicuously by the absence of bright yellow rings round the spiracles. The pupae vary in shape: *P. n. marginalis* is fairly close to *P. n. napi*, but *virginiensis* is radically different; *P. n. oleracea* is intermediate, but tending towards *virginiensis* (Bowden, unpublished). Pupae of the various European *napi* and *bryoniae* subspecies are, on the other hand, practically indistinguishable from one another. The relative length of the antennae also can be used to differentiate subspecies (Bowden, 1971b). The antennae of *P. n. oleracea* are conspicuously shorter than those of four European taxa measured, between which no statistically significant difference is found. *P. virginiensis* is perhaps slightly closer to the European proportion, but the difference from *oleracea* was not significant as measured. *P. n. venosa* shows a "European" antenna/wing ratio, as does *P. n. hulda*. *P. n. marginalis* (Oregon) is intermediate between *oleracea* and European, and differs significantly from both.

It is clear that phenotypic differences at three stages combine to separate *oleracea* from *napi*, even if one disregards the genetically determined melanic patterns above and below the wings. The name *Pieris*

*oleracea* could almost certainly be used in that form without error. But the status of other taxa is not so readily determinable.

Lorković (1970) describes a confusing case in south-eastern Europe. In parts of Yugoslavia resides a population *balcana* Lork., which is phenotypically like *P. napi meridionalis* with some characters of ssp. *pseudorapae* Verity, but which karyologically resembles *bryoniae* and also pairs much more willingly with *bryoniae* than with *P. n. napi*. In the northern Caucasus is another population, *balcarica* Wojtusiak & Niesiolowski, which karyotypically rather approaches *balcana* but shows no reproductive isolation from *P. n. napi*; morphologically it resembles *P. n. pseudorapae* (Lebanon). Now there is as yet no sufficient evidence on which to determine whether Lebanon *pseudorapae* is specifically or only subspecifically distinct from *P. napi napi*, and its karyotype is unknown; hence one cannot decide whether ssp. *balcarica* is a subspecies of *napi* s.s. or of *pseudorapae*.

Where the limits of true species should fall among the groups of subspecies will become better known as the relations between subspecies are explored in search of the evolutionary paths. But at present only scraps of the necessary knowledge are available, and we deceive ourselves if we pretend to have more.

One concludes that for most of the taxa which have ever been included in *Pieris napi* we should continue to use a binomial or a trinomial nomenclature, *Genus species subspecies*, but that when there is still insufficient evidence to decide to what species a particular subspecies belongs, we should instead use the superspecies name in parentheses: *Genus (super-species) subspecies*.

If the subspecies in question constitutes what Kiriakoff (1948) and Lorković (1953) call a semispecies, this style is identical with theirs. Its adoption should imply that a semispecies (while it is considered such) cannot be allowed to have its own subspecies, even under the inappropriate guise of "forms." Indeed, while we are unable to allot a given semispecies to a species, we are unlikely to be able to allot further subspecies to that semispecies with any degree of certainty.

If, however, the subspecies is not considered to be a semispecies, but is merely a taxon of still uncertain affinities, the same style may be used. The resulting slight ambiguity is justified by the rather temporary taxonomic status of the semispecies: in either case the aim must be final reversion to the conventional trinomial.

Nevertheless, in the *Pieris napi* group we find a continuous range of differentiation, from local populations through subspecies to species, which nomenclature cannot fully reflect. The adoption of an arbitrary

criterion for specific status will not change this. Names are labels, and the amount of biological information that they can be expected to hold is limited.

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#### NOTES ON *URODUS PARVULA* (HENRY EDWARDS) (YPONOMEUTIDAE)

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*Urodus parvula* (Henry Edwards) is a common species in Florida and has been recorded from many localities from Miami north to Jacksonville. R. B. Dominick states that the species is also common from March to November at McClellanville, South Carolina. A single specimen in the Cornell University collection from Okefinokee Swamp, Georgia, is apparently the only record from that state. This species may occur along the Gulf coast towards Texas and northward along the Atlantic coast. Forbes (1923) stated, "The northern record (District of Columbia) is based on a single specimen which may have been a stray."

Edwards (1881) referred this species to the genus *Penthetria*, Dyar (1898) placed it in *Trichostibas*, and Forbes (1923) assigned it to *Urodus*. Although only one species of *Urodus* is known from North America, this

TABLE 1. Yearly and monthly occurrence of *Urodus parvula* in light traps at the Archbold Biological Station.

Year	Number of nights traps operated	Dec.	Jan.	Feb.	Mar.	Apr.	May	Totals
1958-59	194	111	140	572	83	—	—	1100
1959-60	79	36	153	120	16	—	—	404
1961	32	—	13	16	4	—	—	33
1962	53	—	23	4	—	—	—	27
1963	68	—	—	3	5	—	—	8
1964	88	—	5	15	23	64	—	107
1965	73	—	14	44	57	56	—	171
1966	113	—	31	36	42	186	—	295
1967	127	—	128	103	269	649	114	1263
1968	136	—	201	44	27	146	270	688
1969	97	13	1	2	8	40	1	65
1970	99	0	1	1	7	63	11	83
Totals	1160	160	710	960	541	1204	396	4244

genus, according to the U.S. National Museum records, is extensive in Central and South America.

The present studies are based on more than 4,000 specimens captured in light traps over a period of twelve years, and some rearings.

Eggs were not found on the hosts but were obtained in rearing chambers. They were laid singly and somewhat scattered on the insides on the rearing chambers and upon filter papers used to control moisture. They are pale yellow, smooth, without sculpturing, 0.74 mm long and 0.37 mm wide.

The larva feeds upon red bay leaves, *Persea borbonia* (L.) Raf., cutting narrow irregular areas. This type of injury was often seen but never appeared abundant enough to cause serious injury to the trees. The larva has also been recorded feeding on southern buckthorn, *Bumelia reclinata* Vent., orange, oak, and hibiscus. The mature larva is 12 mm long, noticeably spiny and somewhat colorful. The head is yellow, the thorax and abdomen have a yellow line on each side formed by a series of irregular yellow spots on the anterior and posterior margins of each segment. The strong dorsal setae arise from conspicuous black pinacula. The prolegs are brown, each with a lateral yellow spot. The setae of the thoracic and prolegs are weak and pale in color.

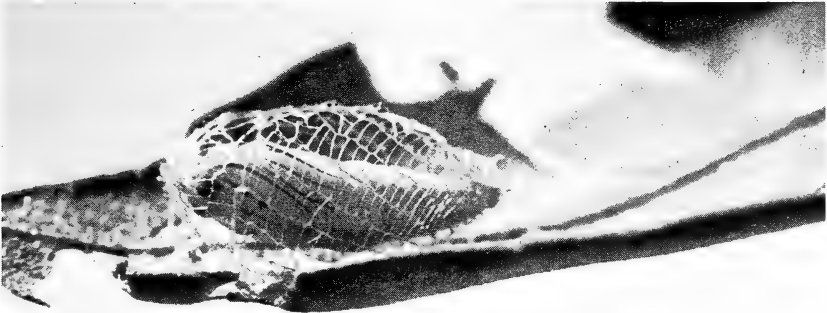
The pupa is formed in a lacy cocoon, oval in shape and somewhat

→

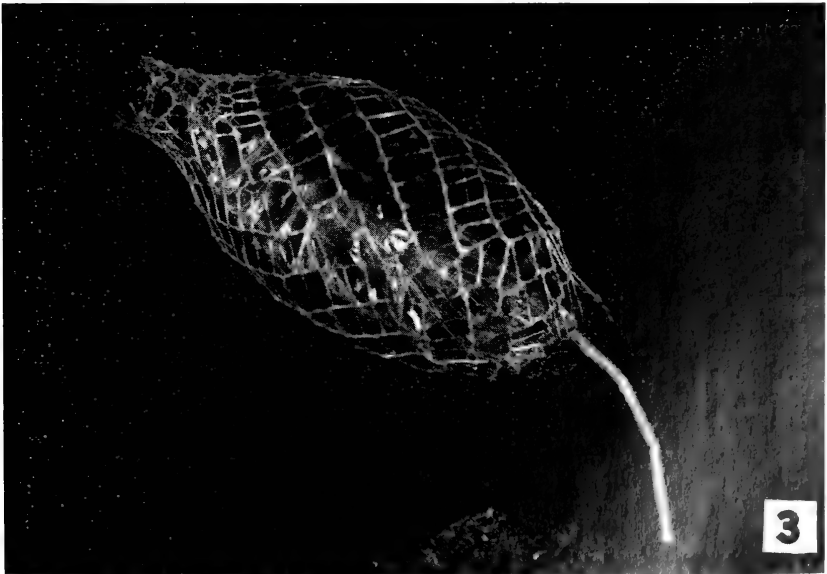
Figs. 1-3. *Urodus parvula* (Henry Edwards). 1, adult  $\times 4$ ; 2, cocoon with pupa  $\times 3$ ; 3, cocoon showing attachment pedicel and cast pupal skin within  $\times 5$ .



1



2



3

TABLE 2. Sex ratios of specimens taken in light traps from 1967 to 1970.

Month	Number of nights traps operated	Males	Females	Totals
December	10	9	4	13
January	95	229	102	331
February	77	99	51	150
March	101	206	95	301
April	113	602	296	898
May	34	188	198	386
Totals	430	1333	746	2079

tapered at the lower end. It is  $13 \times 6$  mm and formed of regular trap-ezoidal meshes supported by a thick thread that extends along the side of the cocoon and is attached to the supporting object.

The adult male and female are similar in color, opaque black, 15 mm long with a wing expanse of 22 to 25 mm. The males are easy to recognize because of their unusually large genitalia and the possession of an indistinct short reddish area at the base of each wing near the costal margin.

Adults were freely attracted to lights. Considerable variation in the abundance of the moths was noted from year to year. These variations could not be correlated with temperature or precipitation but apparently were due to developmental cycles which reached a maximum in 1959 and 1967. Although light-trap catches extended only from December to May, Kimball (1965) has records for June and July and apparently this species has a long period of activity. In general the moths seemed to be especially abundant throughout the winter and spring months. Males were notably more abundant than females. Of 2079 specimens taken in light traps from December 1 to April 30, involving 430 nights over several years, 1333 were males and 746 were females.

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## OBSERVATIONS ON FOODPLANT RECORDS FOR *PAPILIO GLAUCUS* (PAPILIONIDAE)

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Numerous investigators have contributed to a large body of diverse data regarding the choice of ovipositional sites and larval foodplant records for the *Papilio glaucus* L. group of swallowtails. These data have been compiled and summarized by Brower (1958). The field observations described herein were made during the summers of 1968–1971. These observations add still another family of plants to the list of known ovipositional choices for *Papilio glaucus*, the Eastern Tiger Swallowtail, and clarify the records for two genera of plants found in communities associated with populations of *P. glaucus* in southwestern Virginia.

During the summers of 1968–1970 more than 12 observations of oviposition were noted on *Prunus serotina* Ehrhart (Wild Cherry) in Giles and Montgomery Counties, Virginia. Other observations during this time include 6 larvae collected from *P. serotina*. Although *Prunus virginiana* L. (Choke Cherry) is found in the same locality, larvae reared in the laboratory, when given a choice, rejected *P. virginiana* in favor of *P. serotina*. In this test two groups of second instar larvae (10 progeny from each of two females) were placed in rearing dishes containing both species of *Prunus*. During the subsequent 48-hour period no feeding damage was observed on *P. virginiana*. However, the larvae moved about freely and were observed to feed on *P. serotina*. Assuming that these plants are equally acceptable one would expect feeding damage to have occurred on *P. virginiana* and that the larvae would be distributed equally among the two plant species. These observations (20 on *P. serotina*: 0 on *P. virginiana*) differ significantly from the expected (chi-square test).

In contrast, larvae of *P. glaucus* readily fed on both *Magnolia acuminata*

*L.* (Cucumber-Tree) and *P. serotina* when both plants were placed in the same dish. Similarly, observations regarding the ovipositional behavior of *P. glaucus* have also been made on *M. acuminata*. On two occasions in the field, females displayed apparent oviposition on this species; moreover, one of the butterflies appeared to have laid at least 10 eggs in various parts of the tree. Because these butterflies chose the uppermost branches, it was impossible to determine that eggs had actually been deposited. However, during these observations, the entire sequence of ovipositional behavior was normal. Additional evidence that *M. acuminata* is an acceptable foodplant comes from one of the author's (MPL) laboratory studies. In the course of rearing *P. glaucus*, *M. acuminata* was frequently used to elicit oviposition and larvae were reared successfully on this deciduous tree.

Clark & Clark (1951) indicate that *Magnolia* is a favorite food-plant for *P. glaucus* in the southeast; however, neither they nor Brower (1958) identifies the species of *Magnolia*. This seems to be a fairly important gap in the data for many magnolias are evergreens, while *P. glaucus* feeds on deciduous trees. The Cucumber-Tree, *M. acuminata*, is a deciduous tree and seems to fall into the general feeding pattern of *P. glaucus*.

During the summer of 1971 one of the authors (MAA) brought a larva into the laboratory from the wild. It was assumed that the larva was *P. cresphontes* Cramer because it had been located on the hop tree, *Ptelea trifoliata* L. (Rutaceae). Subsequently the authors verified that this was a fourth instar larva of *P. glaucus*. A systematic search of *Ptelea* at the same site, the Sinking Creek area in the vicinity of State Route 700 (Giles Co., Virginia), failed to locate other *P. glaucus* larvae. Further, species of plants which are known to be acceptable ovipositional sites for *P. glaucus* larvae were absent from this locality. Orange dog larvae of *P. cresphontes*, however, were found repeatedly.

A second locality, Spruce Run Valley (Giles Co., Virginia), was also examined to determine the relative frequency of *Ptelea*-feeding. *Ptelea* is abundant along the mouth of this creek; most of the plants are saplings and can be examined rather carefully. Again one *P. glaucus* larva (fourth instar) was collected from *Ptelea*. This larva was also taken to the laboratory and reared on *Ptelea*. One additional case of a *P. glaucus* larva on *Ptelea* has been observed (D.A. West, pers. comm.). It seems unlikely that the occurrence of either of the larvae discovered by the authors could be due to larval migration. The second larva, like the first, was in an area lacking known and suitable ovipositional sites. Finally, in order to obtain some additional information, two *P. glaucus* larvae (both in the third

instar) collected from *P. serotina* were transferred to *Ptelea* in the laboratory. All four *P. glaucus* larvae appeared to develop normally and typical prepupal behavior was observed. The four larvae pupated; of these, one died and three are presently in diapause.

As reported in the literature (Dethier, 1937, 1941, 1953; Hamamura, 1959; Thorsteinson, 1958, 1960), lepidopterous larvae often require specific stimuli to elicit feeding. Moreover, unsatisfactory food plants, those lacking appropriate chemotactic or gustatory stimuli, or possessing repellants, are frequently rejected; thus *P. trifoliata* seems to provide the necessary "token stimulus" and nutritional value for the development of *P. glaucus* larvae. Yet, it seems that the apparent use of *P. trifoliata* as an ovipositional site is not particularly frequent for our extensive search for larvae produced only two. It is probable that the apparent use of these plants as an ovipositional choice is of relatively recent origin since the observations of *P. glaucus* on numerous other deciduous trees has not escaped observation (Brower, 1958; Clark & Clark, 1951). Nevertheless, in this part of Virginia some females may use *Ptelea* on a regular basis, for the trees are found scattered throughout the valleys of Giles and Montgomery Counties, Virginia.

At this time no conclusions can be reached as to the significance of the *Ptelea*-feeding observations. The nature of the foodplant preferences, i.e. whether they are induced or hereditary (Jermy et al., 1968), cannot be determined without observations from carefully controlled experiments. As Jermy et al. (1968) point out, the use of field-collected larval populations for analyses of feeding preferences may result in faulty conclusions. Thus it would seem that further field observations should be undertaken and that a clarification of the alternative hypotheses for foodplant preferences is warranted.

#### ACKNOWLEDGMENTS

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## THE LARVA OF *CHAMYRIS CERINTHA* (TREITSCHKE) (NOCTUIDAE)

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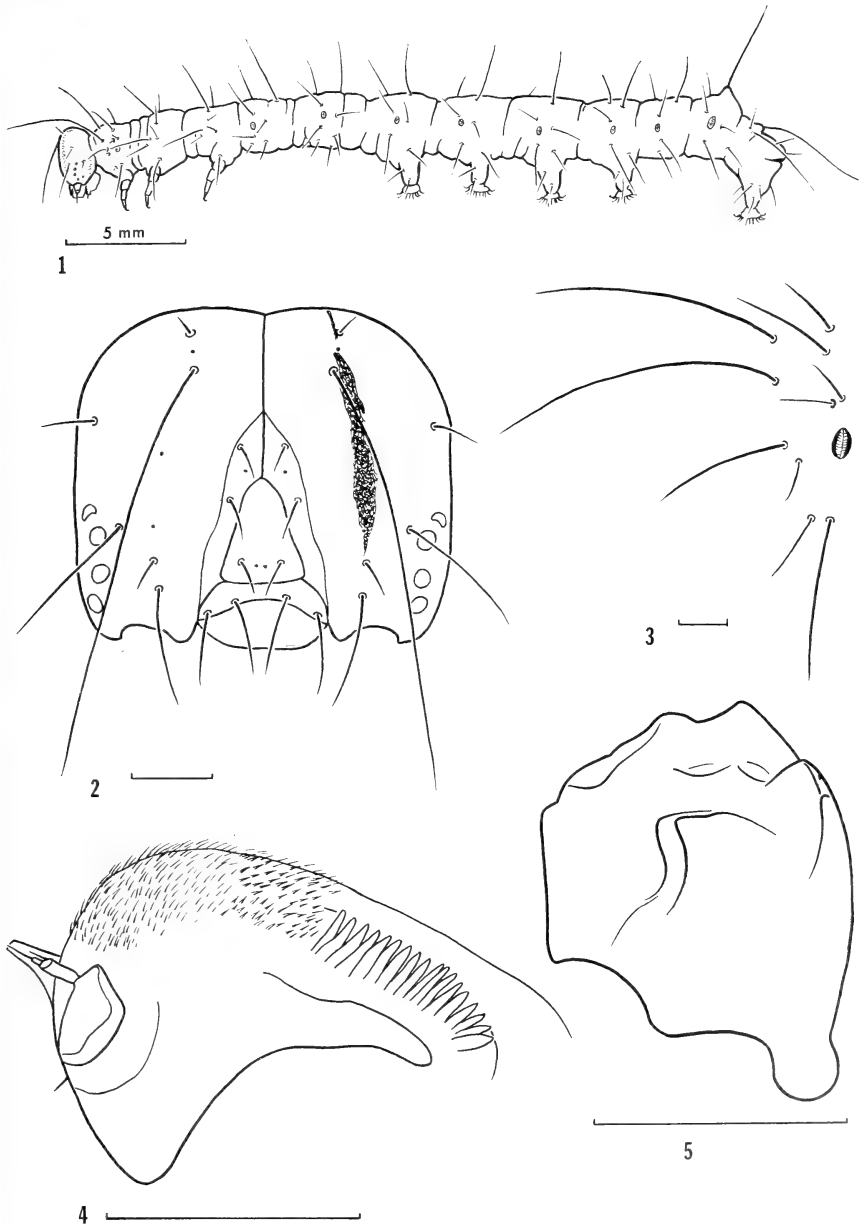
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The larva of *Chamyris cerintha* (Treitschke) previously was described by Coquillett (1881), Forbes (1954), and Crumb (1956). In all instances, the descriptions primarily dealt with general body structure and color. The notes and illustrations in this paper are designed to describe the caterpillar of *C. cerintha* more thoroughly, especially in respect to the mouthparts and chaetotaxy. This is done to further document morphological structures of the larvae of the Noctuidae that I think are of key taxonomic importance, as briefly explained earlier (Godfrey, 1971). In addition, a habitus drawing of the caterpillar (Fig. 1) is provided to facilitate identification of the species.

The illustrations were drawn to scale by a grid system. The scale lines represent 0.5 mm for all figures unless designated differently. The terminology and abbreviations are consistent with those used earlier (Godfrey, 1970).

**General.** Head about 2.5 mm wide. Total length about 32 mm. Abdominal prolegs present on third through sixth segments. Head smooth. Body extensively covered with minute granules. Dorsal abdominal setae simple, very long. Dorsal setae on seventh abdominal segment 6-10 times height of seventh abdominal spiracle; setae on eighth segment 19 times height of spiracle on seventh segment. Dorsal setae on abdominal segments eight and nine borne on distinct tubercles.

**Head** (Fig. 2). Epicranial suture 1.6 times longer than height of frons. Distance from frontal seta (F-1) to frontoclypeal suture 0.5 times distance between F-1's. Adfrontal puncture (AFa) and second adfrontal seta (AF-2) posterior to apex of frons. Anterior setae (A 1-3) forming obtuse angle. Lateral seta (L) slightly caudal



Figs. 1-5. *Chamyris cerintha*, Arlington, Va. 1, left lateral aspect of last instar; 2, frontal aspect of head capsule; 3, left dorsolateral seta arrangement of prothorax; 4, left aspect of hypopharyngeal complex; 5, oral aspect of left mandible.

of transverse line formed by AF-2's. First posterior seta (P-1) definitely caudal of juncture of adfrontal sutures. Interspaces between ocelli (Oc) 1-2 and 3-4 subequal, less than interspace between Oc 2-3.

**Mouthparts.** Oral surface of labrum unspined. Hypopharyngeal complex (Fig. 4): spinneret tapering, not exceeding tip of Lp-2; stipular seta about  $\frac{1}{2}$  length of Lps-1, equal to Lp-1, longer than Lps-2 and slightly shorter than Lp-2; distal region covered with short, fine spines becoming stouter proximad; proximolateral region with distinct row of about 18 large spines. Mandible (Fig. 5) with two closely spaced, large, flat, inner teeth; inner ridges indistinct; six outer teeth present.

**Thoracic segments.** Segment T-1: seta D-2 caudal of line formed by D-1 and XD-2 (Fig. 3); major axis of prothoracic spiracle passing slightly behind seta SD-2 and both subventral setae (SV 1-2); SD-1 in line vertically with setae D 1-2. Segments T 2-3: seta L-1 located above and slightly posterior of L-2. Tarsal claw with distinct basal angle. Tarsal setae with parallel sides and rounded tips.

**Abdominal segments.** Ab-1: only two subventral setae (SV 1, 3) present; SV-1 located posterolaterad of line formed by seta V and SV-3. Ab 2-6: three subventral setae present. Ab-8: only one seta in each subventral group. Ab-9: seta SD-1 as strong as setae D 1-2. Anal and subanal setae no larger than lateral setae on anal proleg. Crochets uniordinal.

**Coloration.** See Forbes (1954) and Crumb (1956) for the color description.

**Hosts.** According to existing records, the caterpillar of *cerintha* feeds only on plants of the family Rosaceae. The recorded hosts are *Crataegus* sp., *Malus* sp. [apple], *Prunus persica* (L.) Batsch [peach], *Prunus serotina* Ehrh. [wild cherry], *Prunus* sp. [wild cherry], *Prunus* sp. [plum], and *Rosa* sp. [rose] (Coquillett, 1881; Lugger, 1899; Forbes, 1954; Crumb, 1956).

**Material examined:** 1 specimen, Arlington, Virginia, July 1949, reared on *Prunus serotina* from ovum from female collected by J. G. Franclemont. Hypopharyngeal complex on slide G-0189.

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## MAXIMIZING DAILY BUTTERFLY COUNTS

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Early in 1967, a preliminary draft of a most interesting paper by Heinz Ebert came into my hands for initial comment. This paper (Ebert, 1970) provided me a great impetus toward the systematization of field collecting techniques, and the proper keeping of records. It was especially valuable in pointing out the great rarity of most species in southern Brazil (and probably in most of tropical America), the preponderance of small, inconspicuous, and/or highly localized butterfly species in the Neotropical fauna, and the advantages of having several collectors in an area at the same time to obtain more complete and representative recording of the species present.

I resolved to try to apply the conclusions of Ebert's paper towards a continuing study of the Lepidoptera of the central Brazilian plateau (see Brown & Mielke, 1967, 1968; Mielke, 1967, 1968a, 1968b). Initially, a complete written list was made of the species (including numbers of each sex) that were captured and positively observed in each collecting day. The following observation of Ebert (p. 6) provided an initial basis for the effort then made to maximize these daily lists:

*"In eastern Brazil the individual frequency of butterflies is generally very low. The success of an excursion is exclusively determined by the number of species found. The higher the number of species found during a trip, the higher the chance to find some regionally (and/or individually) rare species. . . ."*

This suggested that the maximization of daily species lists of butterflies, a seemingly unscientific goal (though much employed in a sister area, ornithology), could give a large scientific fallout; and this has indeed proved to be the case. For the benefit of the butterfly-interested public, both amateur and professional, this paper presents a discussion of the methods used for maximization and the results obtained, including a comparison of various Neotropical collecting areas, both in overall Rhopalocera and in individual family or tribal groups.

Although the collecting methods here described for obtaining maximum daily lists differ in many fundamental aspects from those used by Ebert in his careful long-term studies of the butterfly frequencies in Brazil (which place an emphasis on *averages* rather than on maximum daily lists), the overall results are very similar and further confirm Ebert's conclusions on intensive, extensive, and seasonal abundance of the various groups of Brazilian Rhopalocera. This paper thus represents a supplement to Ebert's full discussion, written from a different point of view, and incorporating data derived principally from about 150 collecting days in 1967–1972 (see Table 1 for a selection of these), with maximum expenditure of energy, using methods of intensive or large-scale area coverage, and efficiency and accuracy of recording, developed and sharpened during ten years of taking ornithological censuses.

## METHODS

### Equipment

It was ascertained early that the routine use of binoculars during the day's collecting (as in ornithology) not only greatly increased the number of butterfly species that could be positively recorded in a day, but also permitted a beneficial redistribution of energy: most larger common species, which could be unequivocally identified even to the sex at long distance with binoculars, did not need to be captured, and physical effort could be concentrated on collecting the smaller and more unusual species present. In general biological terms, the use of binoculars also allowed careful field studies of high-flying species and unusually wary forms or individuals, rarely mentioned in the lepidopterological literature. In a noteworthy case, the female of a new species of Ithomiinae was observed while laying eggs high in a tree; this observation led to publication of the complete biology of the species together with its original description (Brown & d'Almeida, 1970). Many other immature stages have been discovered in this same manner with binoculars. Also, the nearly extinct *Heliconius nattereri* was finally relocated, studied, and bred by the author following a chance long-distance sighting with binoculars of a male in Santa Teresa, Espírito Santo (see Brown, 1970, 1972).

An eight-foot pole length with a four-foot extension (for more open areas), easily manageable in all but the densest woods, is necessary to capture the many high-flying species (which generally belong to groups of localized and little-known forms, especially Lycaenidae<sup>1</sup> and Hesper-

<sup>1</sup> We use the family Lycaenidae to cover the group often discussed as a superfamily, Lycaenoidea (in the Neotropics, the Plebejinae, Theclinae, and Riodininae). Likewise, Nymphalidae = Nymphaloidea of many authors.



idae), which can be discovered with binoculars but not always positively identified.

In addition to the binoculars and lightweight net with aluminum pole, minimal collecting equipment is kept (forceps, a belt box with envelopes, a small poison jar in the pocket) to permit rapid movements and efficient handling of captured specimens. Photographic and breeding equipment are left in a central location; early stages discovered are brought back there during "slack" collecting hours in the late afternoon.

### Planning

In attaining a maximum list in a given region, or seeking to use a limited number of collecting days most effectively, the lepidopterist should work principally in relatively restricted and disturbed wooded areas (see below), and move around a great deal in the initial explorations. The area chosen must be well reconnoitered for paths and roads, streams and sandy banks, flowers inside and outside the forest, clearings within the woods which catch the sun at various times of the day, and accessible forest edges lit by the first and last sun in the day. The latter areas will provide the majority of the day's lycaenids, and the clearings and flowers the majority of the HesperIIDae. A partly cleared hilltop will provide dozens of additional species throughout the day in both these groups, plus many additional and unusual Papilio and Nymphalidae. Baited traps (as many as 30) should be placed along trails and on woods-edges on the evening or night previous to a collecting day. By using traps to capture the many bait-attracted nymphalines and satyrines (a number of which enter during the twilight and dawn hours), the collector can focus his attention on the smaller species which do not catch themselves so easily.

### Collecting Period and Distribution of Energy

In the ideal case, weather and his strength permitting, the collector should work from sunup to dark, leaving the woods edge at sundown (when the Lycaenidae finally sit down for the night) to capture Brasolini at their suspected or prelocated flyways. Thus the condition of maximum effort may be fulfilled, giving the over-all results a measure of consistency. "Slack periods" in the early morning and late afternoon, or during cloudy spells, may be used for resting, moving between collecting areas, and harvesting the traps. In very hot lowland tropical areas (the coastal plain in southeast Brazil in summer, much of the Amazon Basin near the rivers, or lowland Panamá) both butterflies and collectors are often driven into inactivity by the heat between 1100 and 1430; but in

hilly or mountainous regions, both can remain active during most of the daylight hours, with peaks in late morning and mid-afternoon.

A single collector, for best maximization, should move rapidly from habitat to habitat (using a vehicle such as a Jeep to cover greater distances), collecting a number of times during the day in each subarea of the locality chosen. On the other hand, a party of collectors will get more results and tire less during the day if they divide up the locality, each covering one biotope or contiguous area very thoroughly during the entire day.

In view of the great preponderance of small-sized HesperIIDae and LycaenIDae in the Brazilian butterfly fauna (see Table 1, end), the effort to maximize lists requires a heavy concentration on these often ignored groups, using binoculars to locate high-perching individuals and spending much time collecting the many species that visit flowers. As Ebert (1970) has noted, the vast majority of the species in these two families have a very low intensive frequency; even in areas where over 300 species in each family have been recorded over long periods, the maximum day's list under optimal conditions rarely passes 100 species in either family. Casual (non-maximized) collecting usually yields but 10-40 species of LycaenIDae or HesperIIDae in a day; concentration on these groups can raise the levels to 30-80 or more (see Table 1).

## RESULTS

The comparison of results obtained in completing the list for the central plateau before and after the adoption of these methods is instructive. In six weeks' collecting in the planalto, before the use of the maximization method, the author and Nirton Tangerini added only 25 species to the total published list (Brown & Mielke, 1967). Using the methods to maximize daily lists, and thereby collecting preferentially the less noticeable species, the author with Stan Nicolay or Karl Ebert added nearly 300 species to the list in another six weeks' collecting in 1967-1970. The total list for the planalto is now over 950 species (see Table 1); most of the added species are small or inconspicuous forms (Satyrinae, LycaenIDae, and HesperIIDae) which probably would have been passed over in casual collecting.

In two weeks' collecting in Belo Horizonte using these methods in May 1967 (the first real test of maximization), the author added 145 species to the published list for the area (Brown & Mielke, 1967). On one sunny day, 260 species of Rhopalocera were positively identified, over 90% of these being caught.

On the local scale, the maximization method could be used to confirm

a fact well-known to Neotropical lepidopterists but often misunderstood in other areas: the most rich and, surprisingly, often most representative collections are to be made in highly restricted areas of partly cut forest, surrounded by fields and swamps, preferably with many low flowers, and liberally served by paths, roads, and clearings. While the legendary (and often imaginary!) areas of vast virgin tropical forest invariably harbor many unusual and characteristic species, these tend to occur in very low density throughout the forest, and must seek sun at levels unattainable by the collector's net. The best overall collecting is always in small varied woodlots where most species thrive and remain accessible.

On the regional scale (see Table 1), the maximization method revealed that the largest intensive species frequencies for daily lists (though not necessarily for long-term censuses), could be found in the blend zones between the cerrado area of the Brazilian planalto and the adjacent tropical forests of the southeast coastal mountains (as in Belo Horizonte or Poços de Caldas) or the Amazon Basin to the north. The rarer species seemed to be more common in these areas, probably because of the highly varied microclimates and floral niches present in the hilly transition areas between different faunal regions.

In the northwestern blend area between the cerrado and the upper middle Amazon region in central Mato Grosso, preliminary application of these methods in the summer of 1969 suggested that intensive winter collecting might give lists approaching the limits of daily butterfly numbers for the Neotropics. Therefore, when in May 1969 an excursion to the Chapada de Guimarães was made in company with Stan Nicolay, full plans were developed for intensive collecting with maximization methods, both along the way and in the Mato Grosso blend area. The results of this trip (see Table 1) amply confirmed the exceptional position of the Chapada de Guimarães in central Mato Grosso with respect to relative butterfly abundance. This area produced in one day a list of 361 species (307 recorded by the author alone), which, for the time being, stands far above the daily lists obtained by us or others in any other area of the Neotropics or, indeed, in the rest of the World.<sup>2</sup>

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<sup>2</sup> The late Dr. Richard M. Fox claimed to have collected "about 350" species in a single day's collecting near his field station in Liberia (personal communication). As he reports only 450 species for the whole country (Fox, Lindsay, Clench & Miller, 1965), we must conclude that, unless the percentage of rare and localized species in the Liberian fauna is vastly lower than that in the Brazilian fauna, this estimate may be somewhat exaggerated. The author also has a letter from John H. Masters indicating that a list of 350 would be attainable in a single day's collecting in the Amazon Basin. We presume that this would be in the blend areas on its western edges, where the highland and basin faunas meet and mix. The author has visited a number of such areas in Colombia, Peru, Ecuador, and Bolivia; several of them offered the same subjective impression of extreme butterfly abundance that is evident in central Mato Grosso.

A day's total of 350 should be near the limit for a single collector even in such exceptionally rich areas, not due so much to butterfly abundance as to limitations on the speed of moving between ecological niches, and observing, collecting, and enveloping specimens. In some exceptionally varied blend areas on the borders of the Amazon Basin, a party of three or four collectors might be able to pass the limit of 500 species in a single day.

FIGURE 1. Comparisons of some daily counts made with intensive methods in central and southern Brazil, 1967 to 1972 \* = estimated number ( $\pm 5\%$ ), material not fully classified.

Locality	Date	Weather	Flowers	No.	Butterfly Groups																
					col.	mo	br	sat	da	ith	ac	hel	nym	lib	the	pl	rio	pie	pa	hesp	total
Sumaré, Rio de Janeiro (Parque Nacional da Tijuca): Disturbed (mostly) second-ary steep forest, humid canyons, trails and roads; includes good hilltops.	28-III-68	Cloudy, warm	+	2	4	5	9	2	7	4	8	33	0	10	2	7	15	5	63	174	
	9-IV-68	Clear, cold, windy	++	1	2	5	9	1	7	4	8	39	0	16	2	11	15	3	84	206	
	30-IV-69	Clear, cool	++	2	2	4	3	0	1	2	8	27	0	32	0	18	7	5	30	129	
	10-V-69	Clear, warm	++	2	2	1	6	1	7	5	10	29	0	21	0	9	10	5	43	159	
	19-VI-67	Clear, warm	++	1	1	5	6	1	13	3	10	41	0	19	2	23	18	2	62	206	
	9-VII-68	Clear, hot	++	2	1	1	7	0	2	2	9	29	0	20	1	15	16	4	59	166	
	31-VII-67	Clear, warm	++	3	0	6	6	0	9	1	10	46	0	21	1	27	16	4	86	233	
	8-VIII-68	Cloudy, warm	++	1	1	3	7	0	3	3	9	21	0	13	0	19	14	1	78	168	
	12-VIII-67	Partly cloudy	++	1	1	3	6	0	9	1	9	41	0	16	2	15	13	3	88	211	
	13-VIII-69	Partly cloudy	++	1	0	8	8	0	6	4	8	45	0	24	0	25	16	5	107	256	
	15-VIII-70	Clear, warm	++	1	0	2	7	0	1	2	9	29	0	17	1	17	14	3	68	170	
	14-VIII-71	Clear, warm	++	1	0	7	10	2	10	5	10	37	0	28	1	25	20	5	118	278	
	28-VIII-67	Clear, hot, dry	++	1	1	5	8	0	10	1	10	48	0	20	2	20	14	9	81	239	
	16-IX-67	Clear, cold, dry	+	1	1	4	10	0	8	1	9	45	0	20	0	16	11	5	62	192	
NOTE: Peak in midwinter flower season. Large differences between 1967 and 1969 (good years) and 1968 and 1970 (bad years); 1971 extremely good. General abundance of Hesperidae.																					
TOTALS for Sumaré, 40 collecting days					5	13	21	3	29	6	16	75	1	100*	3	80	36	20	250*	658	
Vila Velha, Ponta Grossa, Paraná: Subtropical forest, open fields, marshes.	6-II-68	Clear, warm	+	2	2	4	13	0	6	0	5	11	0	9	1	8	4	3	28	94	
	7-II-68	Clear, warm	+++	2	1	5	8	0	5	1	7	22	0	4	2	5	12	5	48	125	
NOTE: Peak in midsummer. Generally much reduced fauna of these temperate forests, which experience frosts in winter.																					
Curitiba, Paraná: Subtropical forest, swamp.	11-IV-67	Clear, hot	+++	1	3	3	9	2	16	4	11	34	0	7	1	10	19	4	50	173	
	13-IV-67	Clear, hot	+++	1	3	0	9	2	15	3	9	35	0	7	1	13	19	5	46	167	
	30-VII-68	Clear, hot, dry	++	3	1	0	12	0	21	1	9	41	0	18	1	15	16	3	39	177	
	16-IX-68	Clear, hot	++	1	1	0	16	1	17	2	8	44	0	17	1	17	15	3	29	171	
	18-IX-67	Clear, hot	++	1	1	4	12	1	13	1	10	51	0	7	2	18	17	11	31	179	
	19-IX-68	Clear, hot	++	1	1	2	15	1	22	1	9	44	0	10	0	21	20	6	36	188	
	25-IX-68	Clear, warm	++	1	1	3	14	1	21	1	8	40	0	5	0	24	16	4	42	180	
	30-IX-67	Clear, hot	++	1	1	5	15	2	16	0	10	50	0	7	2	9	11	8	23	159	
	1-X-67	Clear, hot	++	1	1	7	16	2	19	2	10	46	0	5	3	11	17	12	16	167	
	3-X-67	Clear, hot, dry	++	1	1	5	14	3	16	1	10	60	0	12	2	16	12	9	25	186	
	NOTE: Peak in late winter and early spring, before heavy rains of October; secondary peak in April flower season. Abundance of Nymphalidae, scarcity of Lycaenidae/Hesperidae.																				
TOTALS for foothill forests near Rio, 15 days					6	14	31	3	33	6	16	80	1	40	3	60	35	24	130	482	

TABLE 1. (Continued)

Locality	Date	Weather	Flowers	No.		Butterfly Groups																	
				col.	mo	br	sat	da	ith	ac	hel	nym	lib	the	pl	rio	pie	pa	hesp	total			
Magé, st. R.J.: Lowland humid forest, swamps, Tiuma, Pernambuco: Moist tropical forest.	3-VII-68	Clear, warm	+++	1	1	1	7	1	9	1	6	32	0	12	3	4	16	5	41	139			
	2-VIII-70	Clear-rainy, hot	++	1	1	5	18	2	4	0	8	36	0	2	0	13	10	0	11	110			
	13-II-68	Clear, warm	+	2	2	3	5	2	1	0	6	12	0	12	1	4	12	12	18	90			
	31-I-69	Clear, warm	+	3	2	2	4	1	0	1	9	12	0	4	0	2	7	3	15	62			
Independência, Petrópolis, state of R.J.: Hilltop in montane forest.	1-V-69	Part cloudy, cool	+	2	0	1	7	0	2	0	3	6	0	15	0	6	5	2	37	84			
	NOTE: Generally depauperate daily fauna, though fairly rich total fauna, of this high, cool region. Much variety in the smaller species. Peak in midsummer (warmer season).																						
	TOTALS for mountain forests near Rio, 28 days																						
	8 10 32 4 26 8 12 83 1 60 2 54 37 18 120* 475																						
Santa Teresa, Espírito Santo: Heavy, steep virgin forest, cold in winter, hot in summer.	11-II-69	Clear, hot	+	2	3	4	10	2	12	1	11	24	0	5	0	11	12	0	23	118			
	12-II-69	Clear, hot	+	2	1	5	15	0	10	1	9	28	0	7	1	12	11	3	19	123			
	20-II-69	Part cloudy, warm	+	1	1	4	17	0	9	0	7	22	0	8	0	15	13	2	25	123			
	22-II-69	Cloudy, warm	+	1	3	4	9	1	13	1	10	20	0	3	1	14	11	1	23	114			
	23-II-70	Part cloudy, warm	+	2	3	5	9	1	12	1	11	22	0	3	0	16	10	3	23	119			
	24-II-69	Part cloudy, hot	+	1	3	4	11	1	15	1	10	19	0	5	0	20	13	1	32	135			
	25-II-69	Part cloudy, hot	+	1	3	6	11	0	13	2	10	22	0	10	0	19	12	1	28	137			
	26-II-69	Part cloudy, warm	+	1	2	4	18	0	6	1	8	23	0	6	0	9	14	4	24	119			
	29-III-70	Clear, warm	+	2	4	4	17	3	5	13	25	0	3	1	17	14	1	23	138				
	1-IV-69	Part cloudy, hot	+	1	5	8	13	0	10	7	8	21	0	3	1	12	10	0	24	122			
	2-IV-69	Clear, warm	+	1	5	5	13	1	7	6	8	28	0	3	0	8	9	0	13	106			
	19-IV-69	Part cloudy, cool	+	1	3	3	9	0	8	5	8	20	0	4	0	10	11	3	15	99			
	9-VI-69	Clear, cool	+	1	1	0	9	2	1	1	5	12	0	4	3	12	8	0	13	71			
	10-VI-69	Clear, warm	+	1	1	0	8	1	7	0	11	13	0	4	2	7	9	2	18	83			
	15-VI-69	Clear, warm	++	1	1	0	7	1	9	0	12	13	0	3	0	6	9	0	18	79			
NOTE: Peak in late summer, before first colder weather. Abundance of Morphos, Brassolini, Heliconiini; scarcity of Lycenidae (especially Theclinae) and Hesperidae.																							
TOTALS for Santa Teresa area, 100 collecting days																							
8 20 40 3 26 7 17 90 1 30 3 70 35 13 150* 513																							
Conceição da Barra, Espírito Santo: Heavy dense virgin forest.	23-VI-68	Clear, warm	++	2	2	2	15	2	12	1	9	22	0	8	0	14	9	0	41	137			
	4-V-69	Clear, hot	+	2	3	0	10	0	6	0	8	24	0	14	2	18	10	1	40	136			
Pedro Canário, Espírito Santo: Remnant of same forest, with flowering fields.	27-VII-67	Clear, warm	++	2	0	0	23	1	12	1	11	29	0	23	0	13	13	0	58	184			
	20-VI-68	Clear, hot	+	2	1	1	26	2	14	1	10	23	1	18	2	10	15	0	48	172			
Mirassol, São Paulo: Semitropical deciduous forest.	5-IX-68	Clear, hot	+	1	0	2	9	1	18	1	3	29	1	4	0	8	11	0	23	110			



TABLE 1. (Continued)

Locality	Date	Weather	Flowers	No. col.	Butterfly Groups														HESP TOTAL	
					MO	BR	SAT	DA	ITH	AC	HEL	NYM	LIB	THE	PL	RIO	PIE	PA		
Jardim Zoológico, D.F.: Low humid forest, marsh, swamp.	24-II-68	Part cloudy, warm	++	2	2	0	9	3	15	0	6	22	1	7	2	9	14	0	36	126
TOTALS for Brasília area, 43 collecting days		NOTE: Peak in autumn.		4	13	45	3	22	6	13	95	1	130	4	130	27	12	250*	755	
São Vicente, Mato Grosso: Heavy forest.	28-V-69	Clear, hot	++	2	1	0	21	2	6	1	8	39	0	14	2	29	11	1	51	186
Buriti, Chapada de Guimarães, Mato Grosso: Heavy forest and sparse moist woods, dry woods, marshes.	22-XII-68 28-XII-68 2-I-69 4-I-69 23-V-69 24-V-69 25-V-69 26-V-69	Part cloudy, hot Part cloudy, hot Cloudy, rainy Clear, cool Clear, hot Clear, hot Clear, hot Clear, hot	++ ++ ++ ++ ++ ++ ++ ++	2 2 1 1 2 2 2 2	2 2 1 1 2 2 2 2	1 1 4 5 3 3 3 3	24 24 32 35 25 32 32 22	0 0 1 1 1 2 2 2	10 10 8 11 12 13 10 10	1 1 4 6 2 2 3 3	3 4 5 4 8 9 10 10	33 39 26 44 44 55 55 64	0 0 16 17 1 1 1 1	17 10 16 17 2 2 2 2	1 0 2 2 4 4 4 4	28 30 12 15 27 42 32 32	13 10 10 15 12 13 15 15	4 3 3 4 3 4 4 4	42 56 190 57 194 220 217 241 259 307	
	27-V-69 31-V-71 4-VI-71 5-VI-70 9-VI-70 15-VI-70 26-VI-72	Clear, warm Cloudy, rainy Clear, warm Part cloudy, hot Part cloudy, hot Clear, hot Clear, hot	++ ++ ++ ++ ++ ++ ++	2 2 1 2 2 2 2	2 2 1 2 2 2 2	2 2 3 3 3 3 3	25 29 29 33 36 36 38	2 2 2 2 2 2 2	12 12 12 13 14 16 16	3 3 3 3 3 3 3	3 8 10 10 6 9 9	5 5 4 5 6 5 5	0 0 4 0 4 1 1	25 10 4 8 15 16 16	2 2 2 2 2 2 2	57 57 12 13 15 14 14	5 5 5 4 6 7 7	122 76 274 71 230 212 292 302 275		
TOTALS for Buriti area, 44 collecting days		NOTE: Peak in late autumn.		2	9	45	4	25	3	14	86	1	50	2	80	20	22	170*	533	
Trail from Salto do Céu to Rio Vermelho, W. Mato Grosso: Highland Amazonian-type heavy forest	1-VII-72 2-VII-72 3-VII-72	Clear, hot Clear, hot Clear, hot	+++ +++ +++	2 2 2	1 4 3	3 4 4	42 41 47	1 1 1	13 12 12	0 0 0	11 13 11	75 87 86	1 1 1	14 9 11	1 1 2	41 30 33	14 15 13	5 7 6	75 87 84	297 309 311
Riozinho, Rondonia: Heavy moist forest	7-VII-72	Clear to rainy	++	3	2	1	29	1	19	1	17	27	0	9	0	36	9	4	61	216
REGIONAL TOTALS over many years' collecting		(First three lists taken from Ebert, 1970)		3	7	23	3	15	2	12	65	1	98	3	76	27	3	194	532	
Eastern Pernambuco—Lowland tropical forest (HE)				7	19	46	5	32	8	14	105	1	88	3	93	44	21	273	759	
Eastern São Paulo—Lowland and mountain forest (E)				6	19	39	4	26	5	15	90	1	117	3	77	38	19	283	742	
Rio de Janeiro and vicinity (low & mt. forest) (HE)				8	20	43	4	38	8	16	115	1	150*	3	115	44	33	350*	948	
Rio de Janeiro and vicinity (author's totals)				4	17	75	4	29	7	13	117	1	150*	4	157	30	24	350*	982	
Cerrado portion of Planalto (excl. blend zones)				8	22	70	4	46	7	17	100	1	100*	3	100*	44	18	250*	790	
Median-littoral humid forest (Bahia, Esp. Santo)				8	37	150*	5	75	15	21	200	1	350*	5	350*	60	57	800*	2134*	
TOTALS FOR EXTRA-AMAZONIAN BRAZIL				8	37	150*	5	75	15	21	200	1	350*	5	350*	60	57	800*	2134*	

## Regional and Seasonal Comparisons by Subgroup (Table 1)

It is of interest to note here the seasons and areas in Brazil, and in other regions in the Neotropics, where, in our experience and based upon these methods of intensive collecting, there may be expected maximum numbers of species in each of the major groups of diurnal Lepidoptera.

**Morphos** in southern Brazil are most common in Santa Teresa, Espírito Santo; all eight species which we recognize in the extra-Amazonian area may be found flying together there in April. Very few other such small areas harbor over six species, and in more subtropical climates these rarely overlap during their single yearly broods in summer. If the same criteria of conspecificity are applied in other regions, eight species may also be captured (though possibly not all at the same season) in some areas of the eastern slopes of the Andes in Peru; and seven species may be found flying together at one time in many warmer parts of tropical America, where most species are multibrooded.

**Satyrines** (including brassolines) seem to be most diversified in areas of alternating dry scrubby woodland and moist riparian forest, with a strong additional element of open grassland and marsh, such as the Chapada de Guimarães and Brasília areas, with 54 and 58 species known to date. Some larger areas have the required diversity to harbor nearly 100 species in this subfamily. A few areas in the Andes may surpass 100 species, though it seems unlikely that more than fifty could be captured in a day. The **brassolines** alone seem most common in hilly areas where neighboring faunal regions meet; the key to their observation and collection is always the discovery of their preferred afternoon and evening flyways and the liberal use of traps with preferred local bait. The area of Santa Teresa has at least twenty species, of which ten have been observed in a single day; we know of no other area in the Neotropics with a similar species abundance. While satyrines and brassolines in general show less strict seasonal variation than other nymphalid groups, individual species often show marked alternations of heavy broods and essentially complete absences. A few temperate-zone species are single- or double-brooded, in summer only.

In Brazil, the maximum number of species of **Ithomiinae** is reached in the median-littoral region, a broad area of moist coastal tablelands in southern Bahia and northern Espírito Santo which shelters many endemic species. Here, 30 species can be found in a single "pocket" in winter, and 25 to 27 can reasonably be collected in a single day. These numbers do not compare with those found in the upper Amazonian and Orinocan tributaries on the slopes of the Andes in Bolívia, Peru, Ecuador, Colombia, and Venezuela, clearly the principal center of geohistorical evolution in



the subfamily. In the Chanchamayo valley (La Merced), Peru, and in north-central Venezuela, the author discovered nearly 50 species present, of which 40 could reasonably be captured in a single day, especially with the use of dried *Heliotropium* plant (Beebe, 1955; Masters, 1968) hung at favored locations within the "pockets." Collection of ithomiines is generally best in the dry season, though a few montane species are most common in the warmer, moist summer season. Many species in the family are notable for their accentuated and unpredictable variations in populations and abundance from season to season and year to year. The localized dry season "pockets," in which all of the species tend to fly together, are much diluted during the wet seasons, and occasionally switch their location dramatically from one year to the next.

The maximum number of species of **heliconians** found in one locality of extra-Amazonian Brazil is 17, in Santa Teresa; 16 of these have been observed in a single day. Again, this compares poorly with the numbers present in some parts of the Andean slopes of Ecuador and Colombia; on the Rio Negro in Meta, Colombia, over 30 species have been found, of which 22 were observed by the author in two days (Brown & Mielke, 1972). **Nymphalines**, many of them attracted to bait, have been found most commonly in extensive and very moist, slightly disturbed forests at the base of the mountains near Rio, and in the interior near Brasília, Buriti (Chapada de Guimarães), and Rio Vermelho (Amazon-type highland forest in western Mato Grosso), but the total lists for an area do not vary much from an average of 80 (locality) or 110 (larger region). The greatest abundance of **Nymphalidae**, broadly speaking, has been observed in Rio Vermelho (161 species in one day); however, if total numbers observed (as a smaller number per day) over a long period is considered, Santa Teresa, which blends four major faunal regions, is much richer.

Almost all tropical nymphalines, including heliconians and charaxines, are to be found most commonly in late summer and fall in cooler areas, and late winter in hotter regions. The genus *Eunica* contains many species that are practically limited to one brood in the late winter. A few larger species of Charaxinae are double- or triple-brooded only, showing much variation in abundance and freshness of individuals caught at different seasons.

For the extensive collection of **Theclinae**, no area can compare with the Brazilian cerrado in the early dry season. Although this habitat has much akin faunistically to an open forest, the trees rarely exceed 20 feet in height, and thus treetop-loving species can be netted easily, together with those preferring low flowers and grass. The spacing of the low trees assures abundant sun all day long, and the interspersal of occasional

denser growth (cerradão), more open areas (campo cerrado), and moist riverside and headwater woods guarantees the presence of a very wide variety of Theclas. The 47 species in this subfamily captured by the author and Karl Ebert in Itirapina, São Paulo, a southern outpost of the cerrado within the blend zone, in May 1967 (Ebert, 1970) represented an early and successful test of some of the methods described in this paper. In a good year (such as was 1972) in the Brasília area, a day's list of nearly 100 Theclas should be attainable by a party of three or four collectors; the maximum to date, with two persons, is 84, and a total lycaenid list of 137 species.

The only areas we have seen to match the forests of the Chapada de Guimarães for **Riodininae** are the lowland woods near Manaus, where 50 species were captured in two days in January 1970, and the swampy woods near Belém, where 45 species were found in two days in late December, 1970. Presumably, an area could be found in the lower middle Amazon which would produce nearly a hundred species of these brightly colored small butterflies in a day. Diversity of flora is a good clue to abundance of Riodininae, and favored male patrolways (hilltops and open moist woods are best) must be located, and hours of flight activity ascertained, to give good collecting.

In Brazil, **Papilionidae** are most abundant at the very beginning of the rainy season in September, especially in the upper Paraguay River basin, where over 20 species could be captured in a day; similar or greater numbers should be attainable in many areas of the upper Amazon basin, as well as in the foothills near Rio de Janeiro at this same season (24 species recorded in Xerém, not all on one day). The fall and winter are very poor in Papilionidae, except for occasional *Parides* in warmer areas.

**Pieridae** have been found most abundantly in the same areas and seasons as Papilionidae; the diversity is greatest in the foothills near Rio where mountain and lowland species mix (44 species recorded, 22 in a single day in Xerém). Outside Brazil, somewhat greater numbers may be encountered in favored seasons on the eastern slopes of the Andes.

**Hesperiidae** appear commonly in almost all Neotropical areas with diversified ecological biotopes (though much more rarely in extensive virgin forests); a daily list of over 100 species should be attainable in any of a number of regions in the good flower seasons. Table 1 shows an extraordinary correlation of numbers of skippers captured with flower abundance, which should be taken to heart by those who specialize in this family. Prominent in the flower groups that bring these butterflies out of the forest and concentrate them in accessible areas are members of the Eupatoriaceae, which flower principally in fall and winter in Brazil.

## SUMMARY

A method for the conscious maximizing of selected daily butterfly lists in southern Brazil has permitted much new information to be obtained on the occurrence and biology of the small, localized, and/or high-flying species in the fauna, which tend to be least known. It also has provided a reasonably standardized basis for comparisons between different localities and seasons, both in overall number of species present and in relative abundance of the various subgroups of Rhopalocera. General conclusions on extensive, intensive, and seasonal frequencies closely match those presented by Ebert (1970), though the collecting methods used are fundamentally different.

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## AN UNUSUAL MOTH IN CENTRAL ILLINOIS

After working on my car, at about 1400 on 14 November 1971, I drove it through a parking lot across the street from my home. I then noticed a large moth clinging to a building, about ten feet off the ground. A closer look revealed that it was a large noctuid. Immediately, I opened the back of the car, grabbed my net, made a lunge at the moth, and managed to capture it.

As soon as I got home, I checked my revised edition of Holland's *Moth Book*, and found that the moth I had just caught was *Thysania zenobia* Cramer. After reading that it was a "South American moth," I knew that I had caught something quite unusual for central Illinois. However, a moderately strong wind had been blowing from the south for several days preceding the capture, and as the specimen was slightly worn, this probably explains its presence this far north, especially at such a late time of year.

I am sure that this capture does not constitute a state record after checking with the University of Illinois and Eastern Illinois University; but it might be a new record at least for Coles County. If any members know of a previous capture of this species in this county, I would sincerely appreciate hearing from them.

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## WING-SHAPE AND ADULT RESOURCES IN LYCAENIDS

Various small species of blues (Lycaenidae: Lycaeninae) are characterized by rather narrow elongated wings—a Nearctic example being *Zizula cyna* Edwards. In September of 1971 some observations were made on a related African species, *Lycaena hylax* (F.) in the Gombe Reserve on Lake Tanganyika, Tanzania.



Fig. 1. *Zizula hylax* crawling into *Asystasia* flower. Margin of hind wing would be even with lip of flower when butterfly has fully entered. The length of the forewing in *Z. hylax* is about 11 mm.

September is near the end of a long dry season at Gombe, and relatively few flowers were in bloom. Prominent among those blooming especially along water-courses, was a small herb *Asystasia gangetica* (L.) T. Anderson in the Acanthaceae (a largely tropical family related to the Scrophulariaceae). Those flowers were repeatedly visited by *Z. hylax* individuals. Their slender wings, when folded back, permitted the butterflies to crawl deep into the corolla to get at the nectar (Fig. 1). The fit was sufficiently tight to make it clear that even slightly wider wings would effectively prevent this behavior.

*Zizula hylax* has a weak flight compared with many small relatives with broader wings and it does not glide. It seems highly unlikely, therefore, that the high aspect ratio of the long slender wings produces a significant selective advantage through its aerodynamic properties. On the other hand, studies by our group in California, Colorado and Trinidad increasingly are showing the great significance of adult resources to the dynamics of butterfly populations. It seems most likely that the adaptive significance of wing-shape in this case is related to access to nectar. Further observations on related species would be most interesting.

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NEW DISTRIBUTION RECORDS FOR *CERATOMIA HAGENI*  
(SPHINGIDAE)

To date *Ceratomia hageni* Grote has been recorded from Arkansas, Kansas, Mississippi, Missouri, and Texas (R. W. Hodges, Sphingidae, in R. B. Dominick et al., *The Moths of America North of Mexico*, Fascicle 21, 1971). The larval food plant, osage orange [*Machura pomifera* (Raf.) Schneid.], has a much greater range, having been planted extensively in the Mississippi valley and eastern United States including New England. The range of osage orange suggests that *C. hageni* should occur over a much greater area than previously recorded.

Upon reviewing my collection of Indiana Sphingidae, I discovered a specimen of *C. hageni* taken 3 Sept. 1960 at lights in Indianapolis. The specimen is a male with a wing expanse of 89 mm and a wing length of 41 mm. Another male specimen of *C. hageni* was taken at Springfield, Ill. on 28 June 1959 (collector unknown). This specimen is in the Natural History Museum of Los Angeles County (J. P. Donohue, pers. comm.).

It is probable that this species has been overlooked since it is similar in maculation to *C. undulosa* (Walker) and *C. catalpae* (Boisduval), which are generally distributed over the eastern part of the United States. *C. hageni* can readily be distinguished from other species of the genus by the green to yellow-green shading of the primaries, midtibia possessing a series of apical spines (sometimes obscured by the vestiture), and fasciculate antennae in the female. Genitalic differences are detailed in Hodges (1971).

This species should be looked for wherever osage orange occurs. The adult is a late flier (Howe, in Hodges, 1971). It is attracted to lights, but does not begin to fly until after 2200. The immature stages need to be studied more completely. Stallings & Turner (1944, *J. Kansas Entomol. Soc.* 17: 29-31) gave a brief description of the egg and larva. One supposed larval specimen is in the United States National Museum. The pupa is unknown. Much more information concerning the distribution and life history of *C. hageni* is needed.

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FURTHER NOTES ON W. H. EDWARDS SPECIMENS IN ILLINOIS  
MUSEUM COLLECTIONS

In view of the taxonomic and historical importance of butterfly specimens studied and named by W. H. Edwards, the location of such material should be placed on record. These notes supplement earlier discussions of the subject by Brown (1964, *Trans. Amer. Entomol. Soc.* 90: 323-413) and Irwin (1966, *J. Lepid. Soc.* 20: 156-162). The Edwards specimens in my collection listed in the latter paper have been permanently deposited in the Illinois Natural History Survey (Irwin, 1971, *J. Lepid. Soc.* 25: 83-84).

The Natural History Survey collection already contained eleven other Edwards specimens. Nine of these were in the collection of Selim H. Peabody, Regent of the University of Illinois from 1880 until 1891, who corresponded and exchanged butterflies with Edwards. The Edwards holograph labels on the Peabody specimens consist only of sex signs and localities, without the names of the species. In this respect they are so unlike Edwards' usual labels that I suspect that the species names were cut off the labels by some later worker. This may have been F. H. Benjamin, since most of these specimens bear Barnes and Benjamin determination labels beside the remaining portion of Edwards' original labels.

In addition to these nine specimens, there are two other Edwards specimens in

the Survey collection whose provenance is unknown. They may have originated from Benjamin Dann Walsh or Cyrus Thomas as well as from Peabody. Walsh and Thomas were state entomologists of Illinois and were correspondents of Edwards. Their collections were the nucleus of the present Survey collection; some of their material may be still extant in it, although it is no longer recognizable. One of these additional specimens is a male *Euptychia gemma* (Hübner) taken by Edwards himself in West Virginia on 11 June 1878.

I have placed identifying labels on yellow paper reading "From/W. H. Edwards" on all of these specimens and they, with the similarly labelled Edwards material that came to the Survey with my collection, make it one of the largest repositories of Edwards butterflies outside the Carnegie Museum, where the Edwards collection itself is preserved.

The Herman Strecker collection in the Field Museum of Natural History contains more than 70 specimens bearing Edwards' holograph labels. I believe that most of these did not originate from Edwards, but were either determined by him for Strecker, or before Strecker received them. One specimen bears Strecker's label stating that he had sent it to Edwards for naming. A number of these specimens were collected by David Bruce in Colorado, and Bruce is given as their source on Strecker's labels. Many of the Edwards labels in the Strecker collection contain only the name and sex of the butterfly, with no statement of locality or collector, and their pins are not the type Edwards used. All of this indicates that Edwards was not their original source. Two specimens bear label reading "This is the writing of/W. H. Edwards. A." "A" was Eugene Murray Aaron, who curated the Strecker collection at the Field Museum during the late 1930's.

The Strecker collection contains other material which does not bear Edward's own labels, but which he had studied as evidenced by Strecker's labels. Some of this latter group of specimens have been identified as members of the type series of their taxa and have been designated and labelled as holo-, lecto- or paratypes by Brown in his studies of the Edwards type material (*loc. cit.* and subsequent papers).

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## BOOK REVIEWS

MICROLEPIDOPTERA PALAEARCTICA: VOLUME 1. CRAMBINAE, by Stanislaw Bleszynski. 1965. H. G. Amsel, H. Reisser and F. Gregor, eds., in 2 parts: text (in German), xlvii + 553 p.; 133 col. pls., Verlag Georg Fromme & Co., Wien. Price: Austrian schillings 1560, Deutschmarks 240 (less if entire series is bought).

The distinguished author specialized on the pyralid subfamily Crambinae for 15 years, paying particular attention to the Palearctic, Ethiopian, Indoaustralian and Neotropical faunas. He was the first European worker to make as complete as possible use in classification of the male and female genitalia, as well as of all other available characters. He also travelled very extensively, visiting all museums and collections where there might be types, as a result of which he was able to correct a great many errors and misconceptions that had crept into the literature since 1758. In all this he strictly followed the International Code of Zoological Nomenclature, which gave his work a sound basis that will ensure its endurance. Perhaps his most valuable work was breaking up the overgrown "wastebasket" genus *Crambus* into which nearly everything crambine had been thrown for over a century (it contained 74% of all species in Staudinger and Rebel), resurrecting a number of Hübner's genera and naming others himself. His most intensive work was, of course, on the Palearctic fauna, and is represented by the volume being reviewed. Dr. Bleszynski's

untimely death in 1969 in an automobile accident was a great loss to science, as well as a great personal loss to many of us. This reviewer had the pleasure of meeting Dr. Bleszynski at various times in Vienna, London and New York, and of working closely with him for many years through a voluminous correspondence. He takes this opportunity to acknowledge the enormous benefit which he received. Any day the mail might bring a letter telling of the discovery of a long-lost type in Leningrad or Berlin, or pointing out that the so-called type in some museum was a specimen caught years after the publication of the original description!

In this volume the Palaearctic Crambinae (including what some authors separate as the Ancyrolomiinae) are divided into 370 species in 49 genera, a far cry from the status of the classification in the Staudinger and Rebel Catalog, the last to cover the whole ground, where the totals are 165 species in 11 genera. Some genera seem somewhat heterogeneous, but at least the problems are clarified, and future workers will doubtless split still further. The type species of all generic names and the type specimens of all nominal species are cited, with the dates and methods of their designations. Generic and species synonymies and keys are given, and there is an excellent terminal bibliography.

The Palaearctic fauna is, of course, extremely important for the study of the Nearctic, since at least 10 genera and 11 species are common to both, while other Nearctic species are extremely close to their Palaearctic counterparts. Obviously we must have full knowledge of the Palaearctic fauna in order to understand our own. Bleszynski's zoogeographic survey is especially interesting in this respect. All of this is true, of course, not merely for the Crambinae but for all of the Nearctic microlepidoptera that have Palaearctic relationships.

The planning and producing of this book, and presumably also of the volumes to come, reflect the greatest credit possible on the editors who conceived the series. All sorts of unexpected things make the volume far more usable and valuable. These include a lexicon of terms in German, English, French and Russian, and an alphabetical list and index of geographic localities and another of abbreviations. The illustrations are divided into three groups: color paintings of adults, male genitalia and female genitalia. In this way illustrations that must be carefully compared with each other are on the same, or adjacent plates, which greatly facilitates their study. I was greatly intrigued by the forethought that provided three bound-in colored ribbons with which to mark the places of the illustrations of a species to compare them with each other. Another superior feature is the numbering of all the species in a single sequence, not in separate sequences by genera. Thus, species No. 136 in the text is illustrated by color painting No. 136, male genitalia no. 136 and female genitalia no. 136, which greatly facilitates getting the picture of the species as a whole. (As far as I know this idea was first used by E. P. Felt at Cornell in an article on North American Crambinae in 1884.) The essential data of each specimen illustrated are given on the legend page. The color paintings, the work of Dr. Gregor, are most beautifully done and printed, and are a pleasure to use. The whole volume sets a very high standard, hitherto unattained.

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AUSTRALIAN BUTTERFLIES, by Charles McCubbin. 1971. Thomas Nelson (Australia) Ltd., Melbourne and Sydney, Australia. vii-xxx + 206 p., 30 text figures, numerous colored illustrations, 1 map. Price: about \$30.00 (U. S.).

BUTTERFLIES OF THE AUSTRALIAN REGION, by Bernard D'Abrera. 1971. Lansdowne Press Pty. Ltd., Melbourne, Australia. 414 p., 2 text figures, numerous colored illustrations, 3 maps. Price: about \$40.00 (U. S.).



These books are the first since "Seitz" was published about half a century ago which illustrate the butterflies of Australia and the Australian region, respectively, in color. It is somewhat unfortunate, however, that the two books were published in the same year, because the coverage of Australia in duplicate could affect the sales of both books. This overlapping is more apparent than real, though, since the McCubbin book deals with the butterflies of Australia, Tasmania and the off-shore islands only, whereas D'Abrera's book deals with the entire Australian region from New Zealand to Weber's line and north to the Solomons and Fiji.

The treatments are quite different, too. McCubbin deals with fewer than 400 species and is able to consider these in much greater detail. D'Abrera, by contrast, must consider at least five times as many names, and the coverage possible under such conditions can be little more than skeletal, concentrating on the identification of the entities, not on their habits or habitats. McCubbin has been able to give much fuller insight on what the butterflies are like in the field, and in general, what they "do for a living." These firsthand observations make the McCubbin book a very readable one.

McCubbin has been able to include the Hesperioidea in his book, whereas space limitations have not enabled D'Abrera to do so. Perhaps because less is known about the habits and life histories of the Australian skippers, the section on the Hesperidae in McCubbin's book is perhaps the weakest one: if any portion of the book seems to have been taken from others' observations, it would be that section, with a few notable exceptions where it was obvious the author had firsthand experience. Much of the identification and observational criteria cited seem to have been drawn from Evans' *Catalogue* and from various of Waterhouse's papers. D'Abrera did not cover the skippers, as stated above, but he does mention the possibility of doing this group in a later companion volume. I have a difficult time seeing how such a book could be done in the same format as the present one: there just aren't that many hesperioids in the Australian region. Perhaps he would have been better advised to either cover the skippers in the present book, thereby adding fewer than 100 pages to it, or perhaps doing a second volume including the Lycaenoidea and expanding his discussions of all species. As it stands now, the weakest part of the D'Abrera work is the coverage of the Danaidae, especially the genus *Danaus*. The other danaids are at least passably covered (though *Euploea* could use a bit more expanded coverage), but the entire book could have been strengthened by adding another page or two of plates and discussion to *Danaus*, perhaps at the expense of *Ornithoptera*. Books are bought for their illustrations, however, and the bird-wings are among the most spectacular of the butterflies—this may have governed the decision to expand the *Ornithoptera* coverage beyond that that was necessary.

Both books are remarkably free of disturbing typographical and other errors. The errata sheet that came along with our copy of D'Abrera rectifies many of these errors, but no such sheet accompanied the McCubbin volume. As is always the case, a few such errors have eluded the authors' scrutiny: McCubbin has "Klak" (rather than "Kluk") as the author of *Danaus*, and he has placed *Pantoporia c. consimilis* (Bdv.) in the correct genus in the text (p. 60), but on the plate the butterfly is listed as "N." (presumably *Neptis*) *c. consimilis* (it is very possible that the plate was done before Eliot's revision of the Neptini was done); D'Abrera describes as new *Hypochrysops emiliae* on p. 335, figures it as "*emilia*" on the preceding page (rectified in the errata sheet) and lists it as "*emilia*" in the index on p. 407 without correction. To further belabor the authors for these small errors would be nit-picking. In one instance, however, McCubbin has corrected a long-standing nomenclatorial error: Bethune Baker described *Ogyris waterhousei* in 1905 (Trans. Entomol. Soc. London: p. 273), and McCubbin has correctly cited it; D'Abrera has followed the logical, but incorrect emendation to "*waterhousei*." None of these errors is serious, and they in no way detract from the usefulness of either book.

McCubbin's illustration of food plants is very useful, particularly for the collector who might want to find the species in the field. This is an innovation which could be followed to advantage by other illustrators in the future. Perhaps the most impressive coverage of the D'Abrera book involves the Lycaenidae: he has made sense of a group that has stymied many of us attempting to identify these beautiful, but confusing, insects. The fact that many of the new taxa described by D'Abrera in the text are lycaenids indicates that he probably specializes in the group, and his careful handling of the Lycaenidae shows an expert's touch.

Both books owe much of their usefulness to their colored illustrations. It is difficult to imagine how the paintings depicted in McCubbin's book could have been improved upon, and I only wish I had the opportunity to see the originals! The illustrations in D'Abrera's book were derived from Ektachromes and are subject to some color shifts on some, but not all plates. The color shifting may be the fault of the original transparencies or they may be the fault of the printer — there's no way of determining this from long distance. Comparison of the plates with actual specimens at hand shows that the color shift, when it occurs, involves the blue; the blue shows up poorly in the figures of the pierid genus *Saletara*, but the blue is too intense in several of the Satyridae. If one does not take absolute color values too seriously (and it would be dangerous to do so in taxonomic work, anyway), the D'Abrera plates lose none of their usefulness.

From a purely personal standpoint, I wish D'Abrera had used either "upper surface" or "dorsal" for the "recto" he utilizes, and that he had used either "under surface" or "ventral" for "verso." His terms are not in general usage, and the reason for using them instead of more familiar terms is obscure.

The McCubbin book supplements the fine little *Australian Butterflies* by I. F. B. Common (1964, Brisbane, Jacaranda Press) with the excellent colored illustrations and in more detailed discussions of the species. D'Abrera, by contrast, has put out a book that has no "post-Seitz" counterpart, with the exception of Barrett and Burns' *Butterflies of Australia and New Guinea* (1951; Melbourne, N. H. Seward), a book with almost nothing to recommend it scientifically and little more esthetically.

I would very much like to see D'Abrera (or someone equally competent) do a companion volume of the butterflies of Indonesia, or at least from Celebes westward, where the book could bridge the gap between his present volume and Corbett and Pendlebury's *Butterflies of the Malay Peninsula*. If this were done a great deal of the mystery surrounding the Indo-Australian fauna would be cleared up for those of us interested in these butterflies, but without ready access to the great European collections. It is very difficult to envision what McCubbin can do for an "encore" to produce another book of the quality of the present one, unless he undertakes one on the beautiful Australian diurnal moths.

On balance both books are excellent, and if the budget can take something in excess of \$70.00, the interested lepidopterist should have both. If, however, economics of this magnitude are the deciding factor, the reader must determine what his interests are and be guided by them. If he wants identification of Australian butterflies, either book will do, or he can get by with Common's little book; if he wants the finest pictures of Australian butterflies and information on their habits, he should buy McCubbin's book; if his interests go beyond the confines of Australia and he wants more than adequate figures and updated nomenclature, he should buy D'Abrera's book. As an artistic masterpiece and for workers on Australian butterflies in general, McCubbin's book is the best available. The regional scope of D'Abrera's book and its greater scientific "meat" make *Butterflies of the Australian region* the greater prize. Buy either, you won't be disappointed. In any event, "Seitz" is no longer a "must" for the interested lepidopterist's library.

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THE ZOOLOGICAL MISCELLANY, by John E. Gray, with an introduction by Arnold G. Kluge. Reprinted by the Society for the Study of Amphibians and Reptiles. 1971. P. viii + 86, 4 pls. Price: \$8.00 paperbound, \$10.00 clothbound. (Available from the society's publications secretary, Dr. Henri C. Seibert, Dept. of Zoology, Morton Hall, Ohio University, Athens, Ohio 45701.)

This rare natural history journal was published privately by John Edward Gray in London, appearing irregularly between 1831 and 1844. The reprint includes an editorial note about the publication dates of the three parts, and a two page introduction giving some insight into Gray's life and the circumstances which may have prompted him to publish "The Zoological Miscellany." Most of the papers are by Gray himself. There are only three (of 56) papers which deal with Lepidoptera.

GEORGE ROBERT GRAY. 1831. Descriptions of eight new species of Indian butterflies, (*Papilio*, Lin.) from the collection of General Hardwicke. p. 32-33. (Descriptions of *Papilio glycerion*, *Papilio philoxenus*, *Papilio minereus*, *Parnassius hardwickii*, *Pieris horsfieldii*, *Pieris agathon*, and *Argynnis childreni*, all from Nepaul, and of *Papilio agestor*, from Sumatra.)

JOHN EDWARD GRAY. 1831. Description of a new species of *Bombyx* from Nepaul, discovered by Dr. Wallich. In the collection of Major General Hardwicke. p. 39. (Description of *Bombyx wallichii*.)

EDWARD DOUBLEDAY. June 1842. Characters of undescribed Lepidoptera. p. 73-78. (Descriptions of *Papilio ganesa*, from Nepaul, Assam; of *Papilio polyeuctes*, *Papilio xenocles*, *Pieris thestylis*, *Pieris lalage*, and *Rhodocera lycorias*, all from Silhet; of *Leptalis atthis* from Mexico; of *Leptalis cydno*, locality unknown; of *Pieris ianthe* from Sierra Leone; and of *Pieris anactorie* from South Africa.)

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## NOTES AND NEWS

### PROPOSED AMENDMENTS TO THE CONSTITUTION OF THE LEPIDOPTERISTS' SOCIETY

The following changes in the Constitution of the Society have been proposed, in order to:

- 1) qualify the Society as a nonprofit organization;
- 2) establish the new class of Student Member;
- 3) define more precisely the nature of what is now known as Honorary Membership;
- 4) add the Secretary-elect and Treasurer-elect to the Executive Council;
- 5) provide for the nomination by the Nominating Committee of up to two candidates for each elective office, and to simplify the nominating procedure; and
- 6) clarify or modernize several sections.

Notice is hereby given, in accordance with Article XII, Section 1, that these proposed amendments to the Constitution will be sent to the members with the ballots in November, 1972. Each section containing a proposed change is reproduced below in full, with language to be deleted in **bold-face type**, and new language in *italic*.

Article II, Section 1: *The Lepidopterists' Society is a non-profit educational and scientific organization.* It shall be the purpose of the Society to promote inter-

nationally the science of lepidopterology in all its branches; to further the scientifically sound and progressive study of Lepidoptera; to publish periodicals and other publications on Lepidoptera; to facilitate the exchange of specimens and ideas by both the professional worker and the amateur in the field; *and* to secure cooperation in all measures tending to that end. **and to facilitate personal intercourse among its members.**

Article III, Section 2: All individual subscribers to the "Journal" and the "News of the Lepidopterists' Society," who have paid their current **annual** dues, shall be deemed members of the Society.

Article III, Section 3: The membership of the Society shall consist of **four five** classes—Active, *Student*, Sustaining, Life, and Honorary *Life* members. All persons who joined the Society before January 1, 1948, shall be designated Charter members.

Article III, Section 4: Application for Active, *Student*, Sustaining, and Life membership in the Society, received by the Secretary or Treasurer and accompanied by the **annual appropriate** dues for the current year, shall constitute formalization of membership, and no nomination or election to membership shall be necessary. The annual *and Life* dues shall be fixed by the By-Laws.

Article III, Section 6: Individuals who have made important contributions to the science of lepidopterology may be elected Honorary *Life* Members of the Society. There shall not be more than ten living Honorary *Life* Members.

Article IV, Section 1: The officers of the Society shall consist of a President, President-elect, three Vice-Presidents (not more than one **of whom** *Vice-President* shall reside in one country), a Secretary, a Treasurer, a Secretary-elect and/or a Treasurer-elect, in these two offices, in years when there are incumbents.

Article IV, Section 2: The business and affairs of the Society, not otherwise provided for, shall be controlled by an Executive Council, consisting of the President, President-elect, three Vice-Presidents, the Secretary, *the Secretary-elect*, the Treasurer, *the Treasurer-elect*, and nine other members of the Society. Action on all amendments to the By-Laws and all appointments and elections by the Executive Council shall be obtained by a canvass by the Secretary of all members of the Council.

Article V, Section 1: The President shall before the first of July appoint a Nominating Committee who shall nominate **one no more than two** candidates for each elective office to be filled for the ensuing year. **and a list thereof shall be published in one of the Society's periodicals or mailed to the members at least sixty days before ballots are mailed by the Secretary.** Additional candidates may be nominated by submission to the Secretary of written nominations signed by not less than ten members. Ballots containing all nominations shall be mailed in November of each year, setting forth the officers to be elected and the names of those nominated for each office. If more than one person is nominated for any office, their names shall be arranged alphabetically on the ballot.

Article V, Section 3: Election of Honorary *Life* Members. Honorary *Life* Members shall be nominated by the unanimous vote of the members of the Executive Council. The nominee shall be voted on by mail ballot distributed to all members of the Society and reported in one of the Society's periodicals, and must receive 80% of all ballots cast to be elected. Not more than five Honorary *Life* Members may be elected at the first annual meeting, and not more than two in any one calendar year.

#### Article XIV. *General Prohibitions*

*Section 1. Notwithstanding any provision of the Constitution or By-Laws which might be susceptible to a contrary construction:*

- (a) *The Society shall be organized exclusively for scientific and educational purposes;*
- (b) *the Society shall be operated exclusively for scientific and educational purposes;*
- (c) *no part of the net earnings of the Society shall or may under any circumstances inure to the benefit of any private individual;*

- (d) no substantial part of the activities of the Society shall consist of carrying on propaganda, or otherwise attempting to influence legislation;
- (e) the Society shall not participate in, or intervene in (including the publishing or distributing of statements), any political campaign on behalf of any candidate for public office;
- (f) the Society shall not be organized or operated for profit;
- (g) the Society shall not:
  - (1) lend any part of its income or corpus, without the receipt of adequate security and reasonable rate of interest, to;
  - (2) pay any compensation, in excess of a reasonable allowance for salaries or other compensation for personal services actually rendered, to;
  - (3) make any part of its services available on a preferential basis to;
  - (4) make any purchase of securities or any other property, for more than adequate consideration in money or money's worth, from;
  - (5) sell any securities or other property for less than adequate consideration in money or money's worth to; or
  - (6) engage in any other transactions which result in substantial diversions of its income or corpus to; any officer, member of the Governing Board, or substantial contributor to the Society.

*The prohibitions contained in this subsection (g) do not mean to imply that the Society may make such loans, payments, sales or purchases to anyone else, unless such authority be given or implied by other provisions of the Constitution or By-Laws.*









## EDITORIAL COMMITTEE OF THE JOURNAL

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Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

**Text:** Manuscripts should be submitted in *duplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white,  $8\frac{1}{2} \times 11$  inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

**Literature Cited:** References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural Selection and Heredity. 2nd. ed. Hutchinson, London. 209 p.

——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. Adv. Genet. 10: 165–216.

In the case of general notes, references should be given in the text as, Sheppard (1961, Adv. Genet. 10: 165–216) or (Sheppard 1961, Sym. Roy. Entomol. Soc. London 1: 23–30).

**Illustrations:** All photographs and drawings should be mounted on stiff, *white* backing, arranged in the desired format, allowing (with particular regard to lettering) for reduction to their final width (usually  $4\frac{1}{2}$  inches). Illustrations larger than  $8\frac{1}{2} \times 11$  inches are not acceptable and should be reduced photographically to that size or smaller. The author's name, figure numbers as cited in the text, and an indication of the article's title should be printed *on the back* of each mounted plate. Figures, both line drawings and halftones (photographs), should be numbered consecutively in Arabic numerals. The term "plate" should not be employed. *Figure legends* must be typewritten, double-spaced, *on a separate sheet* (not attached to the illustrations), headed EXPLANATION OF FIGURES, with a separate paragraph devoted to each page of illustrations.

**Tables:** Tables should be numbered consecutively in Arabic numerals. Headings for tables should not be capitalized. Tabular material should be kept to a minimum and must be typed *on separate sheets*, and placed following the main text, with the approximate desired position indicated in the text. Vertical rules should be avoided.

**Proofs:** The edited manuscript and galley proofs will be mailed to the author for correction of printer's errors. Excessive author's changes at this time will be charged to authors at the rate of 75¢ per line. A purchase order for *reprints* will accompany the proofs.

**Page Charges:** Authors with grant or institutional funds are requested to pay a charge of \$24.00 per printed page (including tabular and black-and-white illustrative material) for articles up to 20 pages in length. This charge may be waived in the case of authors who have no grant or institutional funding, as it is not intended that any author should pay this charge from personal funds. However, all authors will be requested to pay this charge for material in excess of 20 printed pages.

Address all correspondence relating to the *Journal* to the editor. Material not intended for permanent record, such as current events and notices, should be sent to the editor of the *News*: Dr. C. V. Covell, Department of Biology, University of Louisville, Louisville, Kentucky 40208.

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15 December 1972

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### *Memoirs of the Lepidopterists' Society*, No. 1 (Feb. 1964) A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA

by CYRIL F. DOS PASSOS

Price, postpaid: Society members—\$5.00, others—\$7.50; uncut, unbound signatures available for interleaving and private binding, same prices; hard cover bound, members—\$8.00, others—\$10.00. Revised lists of the Melitaeinae and Lycaenidae will be distributed to purchasers free (separately with paper covered copies and unbound signatures, bound in with hard covered copies).

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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## THE KARL JORDAN MEDAL

LEE D. MILLER

Allyn Museum of Entomology, 712 Sarasota Bank Building, Sarasota, Florida 33577

Several scientific organizations have established prizes for research excellence in their respective fields, such as the Brewster Medal given for meritorious research in ornithology. Such a prize has not been offered in the past for lepidopterology, but in recognition of the 25th Anniversary Celebration of the Lepidopterists' Society, Mr. A. C. Allyn offered to fund such an award through the Allyn Museum of Entomology, Sarasota, Florida. This offer was accepted by the Executive Council and the members in attendance at the Annual Meeting of the Society in San Antonio, Texas.

The award to be given by the Lepidopterists' Society in recognition of outstanding original research in lepidopterology will emphasize particularly the fields of morphology, taxonomy, zoogeography and what was once known as "natural history." These fields are the ones in the study of Lepidoptera that are currently poorly supported and not "popular"; it is hoped that the establishment of this award may encourage workers to do meaningful research along these lines. The prize will consist of an engraved silver medal of appropriate design, a \$1,000.00 cash award and travel expenses for the recipient(s) to accept the award at the particular year's Annual Meeting of the Society.

This award will be known as "The Karl Jordan Medal." There is much to recommend honoring this man in this way. Dr. Jordan was one of the original Honorary Life Members of the Lepidopterists' Society. He was active in the field for over half a century, and during this period he produced an almost unbelievable volume of work of the highest quality. He was honored by The Royal Entomological Society of London with a Jubilee Volume prior to his death, the only man in recent history so honored, attesting to Karl Jordan's preeminence among 20th Century lepidopterists, and entomologists in general. Dr. Jordan did not limit

his efforts to a single fauna, but rather worked on a worldwide basis; neither did he restrict himself to a narrow group of insects: Jordan began his career at Tring as a coleopterist, later became a lepidopterist and still later established his credentials as the world's leading authority on Siphonaptera (fleas). Finally, but by no means leastly, Karl Jordan excelled in those fields previously mentioned for emphasis in the awarding of the Medal and in general exemplifies the ideals for which The Karl Jordan Medal is intended.

The procedures and criteria for awarding the Jordan Medal are as follows:

1. An award committee will be established consisting of:

- A. One representative to be designated by the Allyn Museum of Entomology;

- B. The President of the Lepidopterists' Society, unless he is affiliated with the Allyn Museum of Entomology, in which case the First Vice President of the Society will be part of the award committee; and

- C. An elected member of the Lepidopterists' Society to be known as "the Jordan Medal Representative" who will serve a one-year term and will not be affiliated with the Allyn Museum of Entomology.

In practice, the President-Elect of the Society and the Allyn Museum representative should be in consultation on a short list of nominees for the succeeding year to be presented to the Jordan Medal Representative, who will have less than six months in which to make up his mind on possible candidates.

2. The medal will be awarded only by the *unanimous* vote of the committee. This, of course, will result in the medal not being awarded in some years, but it is felt that the requirement for unanimity of the committee will be a safeguard in assuring that only work of the highest quality is awarded.

3. The award will be for original research, not for the compilation of already known facts. The judgment of where the line must be drawn between research and compilation will be left to the discretion of the committee and may be expected to change from year to year as different people are involved.

4. The award may be based upon a single piece of research or on a series of interrelated works, and the work must be at least three, but not more than twenty-five years old. This stipulation was suggested to assure that awarded work had stood the test of time and use, but it was the most controversial criterion for the award at the San Antonio meetings.

The Jordan Medal is not intended to be a career award; the Society already has such an award, Honorary Life Membership. However, this does not preclude awarding the Medal to an Honorary Life Member for a particular piece of work or for a series.

5. Jointly awarded prizes will be allowed only in instances of co-authorship, and the cash prize for that year will be divided equally between the workers or their heirs. In instances of jointly awarded prizes, duplicate medals will be presented, and travel expenses for more than one worker will be allowed.

6. No member of the Jordan Medal award committee will be eligible to receive the prize during his tenure, but will not be ineligible in succeeding years.

7. The recipient of the Jordan Medal need not be a member of the Lepidopterists' Society. It is hoped, however, that if the recipient is not a Society member that he may elect to become one.

8. Nominations for recipients of the Jordan Medal will be accepted from any member of the Lepidopterists' Society and should be sent to:

Jordan Medal Awards Committee  
Allyn Museum of Entomology  
712 Sarasota Bank Building  
Sarasota, Florida 33577, U. S. A.

It would be helpful to the awards committee if one or more copies of the nominated works were submitted to the same address for distribution to the award committee.

The Karl Jordan Medal will be funded on a year-to-year basis for the time being. There are some problems with professional rivalry and ill-feelings associated with some of the similar prizes in other disciplines; it is hoped that lepidopterists do not become entangled in such unpleasant and unfortunate traps. Should this award show promise of encouraging workers and aiding good relationships between lepidopterists, the Karl Jordan Medal will receive permanent funding in the future. Cooperation, good relationships with fellow workers and excellence were three of the many fine attributes of Karl Jordan and must be fostered in the awarding of the prize that bears his name.

ULTRAVIOLET PHOTOGRAPHY AS AN  
ADJUNCT TO TAXONOMY<sup>1</sup>CLIFFORD D. FERRIS<sup>2</sup>

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Several papers have been published on the use of ultraviolet (uv) photography to visualize hidden characters on the wings of Lepidoptera (e.g. Nekrutenko, 1964, 1965; Eisner *et al.*, 1969). These hidden patterns probably relate to differing characteristics of the scales and their arrangement on the wings. Some work has been carried out using a scanning electron microscope to detect differences in scale characteristics (Kolyer & Reimschuessel, 1969). Most of the more recently published papers have treated the Coliadinae, especially the genus *Gonepteryx*. In this subfamily, luminous patches appear on the dorsal surfaces of the wings when they are photographed under ultraviolet light. In other genera, *Papilio* for example, forms which appear quite different when viewed under white light appear nearly identical when photographed under uv light.

Photographic techniques are necessary to visualize the ultraviolet evoked patterns as the human eye does not respond to that portion of the electromagnetic spectrum. From analysis of black light response in Lepidoptera, their visual perception ranges seem to peak in the range 300–400 nanometers (millimicrons).

Since most of the readily available literature on ultraviolet photography of insects does not give details of technique, it is felt that a technique should be described which could be applied by anyone with a basic knowledge of photography. That is the purpose of this paper.

The primary prerequisite is a camera which has a lens that will pass uv. Generally the better quality modern 35 mm single-lens-reflex cameras from Germany and Japan meet this criterion. The author uses two different models of Mirandas with Soligor-Miranda lenses. A simple way to check a lens for uv transmission (other than by taking a photograph) is to use the lens to focus light from a uv source onto a fluorescent object. Suitable objects are the mineral Willemite ( $\text{ZnSiO}_4$  which fluoresces bright green), if available, or various greases. Vaseline fluoresces a pale green. Fluorescent spray paint also may be used.

Since only ultraviolet reflectance is of interest for distinguishing patterns

<sup>1</sup> Published with the approval of the Director, Wyoming Agricultural Experiment Station, as Journal Paper no. JA 503.

<sup>2</sup> Research Associate, Allyn Museum of Entomology, Sarasota, Florida.



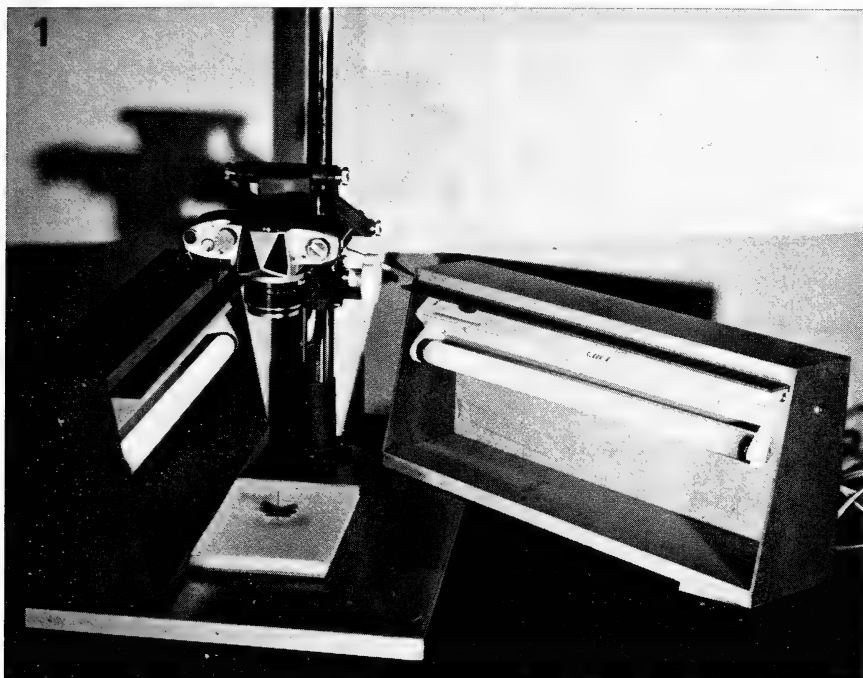


Fig. 1. Camera support and illumination system for ultraviolet photography. Righthand light source swung out to expose mounting technique.

in the Lepidoptera, it is necessary to filter out all light except that in the near uv spectrum (300–400 nm). This may be done with a Wratten 18A filter (Eastman Kodak Co.). This filter is available as a 2" × 2" square and appears opaque. A filter-holder adapter mount is required for the camera. These items can be ordered through any photographic store. The 18A filter transmits ultraviolet light, but blocks visible light.

A suitable light source is necessary. Photographs can be taken in direct sunlight utilizing the uv content of natural light. Generally speaking, light which has passed through window glass should not be used, as most glass filters out ultraviolet rays. For an artificial source, the author uses two 15 watt blacklight fluorescent tubes that have a built-in filter glass which filters out most of the visible portion of the light spectrum. These are model 50058 available from Ultra-Violet Products, Inc., 5114 Walnut Grove Ave., San Gabriel, California 91778. Similar tubes are manufactured by various lamp firms and can be obtained from lamp jobbers.

Fig. 1 shows a simple setup for doing ultraviolet photography. The



Fig. 2. Dark ♀ form of *Papilio g. glaucus* photographed under uv illumination.

light sources are mounted in two homemade wooden reflector housings. Standard 15 watt fluorescent light brackets are used (available from most mail-order catalog stores or from electrical suppliers). A 35 mm photographic enlarger easel is used to support the camera. If available, a Polaroid Camera Corp. copy stand makes an ideal setup as only the 15 watt blacklight tubes are required as additional items. A conventional camera tripod can be used as a camera support, but is less convenient than an enlarger easel. In Fig. 1, one of the lamp housings has been swung out to illustrate the lamp mounting. The lamp appears white in color as the light was on when the photograph was taken. To insure photographing the full extent of the uv reflectance pattern with this setup, specimens must be mounted with the wings flat.

Either Tri-X or Panatomic X film (Eastman Kodak Co.) is suitable for uv photography. The former requires much shorter exposure time than the latter, but tends to develop slightly more granularity. Exposure time can be determined by placing the 18A filter over the light entry port of a CdS exposure meter and measuring the reflected light from the specimen. The background to which the specimen is pinned should not be fluorescent. The high-density polyethylene foam usually used in pinning trays is satisfactory. A typical exposure setting for Tri-X film (ASA 400)

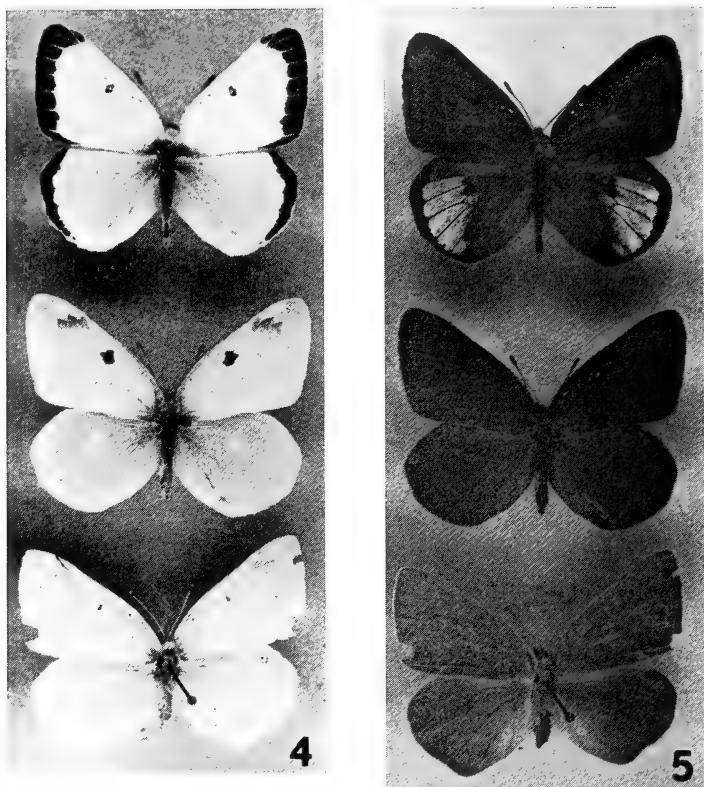


Fig. 3. Normal yellow ♀ form of *Papilio g. glaucus* photographed under uv illumination.

is  $f/16$  at  $\frac{1}{2}$  second with 10 inches between the filter plane and the specimen, and with the light sources approximately 6 inches from the specimen. The camera lens should be stopped down to at least  $f/8$  to produce sufficient depth of field to counteract the difference between focusing white light and near ultraviolet light. Focusing is achieved by removing the 18A filter. If required, a supplementary closeup lens such as a 3+ Portra lens (Eastman Kodak Co.) can be added. This lens does transmit uv light.

Excluding the camera body, lenses, light meter, and stand or tripod, the present cost of setting up to do ultraviolet photography is as follows: 18A filter and holder \$25.00, two 15 watt uv tubes \$14.00, fluorescent lamp fixtures \$15.00, miscellaneous (reflector housings, etc.) \$5.00. These are approximate prices. Special ultraviolet-transmitting lenses are available, but these are designed for very short wavelengths and range in cost from \$750.00 to \$1,600.00. Such lenses are not required for this type of insect photography.

Figs. 2 and 3 illustrate one aspect of uv photography. The two female forms of *Papilio glaucus glaucus* Linnaeus are shown as they appear under uv light. Similar patterns appear when they are photographed



Figs. 4 & 5. Specimens of *Colias a. alexandra* from Albany Co., Wyoming: 4, photographed under normal illumination—male at top, yellow female in middle, white female form at bottom; 5, same specimens as they appear under uv illumination.

under uv illumination, although they are quite different when viewed by visible light. Only a suggestion of the black bars appears in the yellow female form in the ultraviolet photograph.

As a comparison, the wings of both sexes of *Colias alexandra alexandra* Edwards are shown as they appear when photographed with visible light (Fig. 4) and with ultraviolet light (Fig. 5). Under uv light, luminous patches appear on the hindwings of the male, while the female appear drab (a characteristic of the female sex in most North American *Colias*). A forthcoming paper by the author on the *Colias alexandra* complex will demonstrate the utility of ultraviolet photography in taxonomic research.

More sophisticated techniques do exist for ultraviolet photography, but these involve the use of special light sources and filtering techniques. Such matters are beyond the scope of this presentation. The intent here

has been to describe a simple method which can be applied using a limited amount of equipment.

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- Basic scientific photography. Eastman Kodak Co. Pub. N-9.

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## A NEW SUBSPECIES OF *EUMEDONIA EUMEDON* (LYCAENIDAE) FROM CAUCASUS

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During the past few seasons I have had the opportunity to collect in the Western part of the Main Caucasus Ridge and to review Caucasian material deposited in the Lepidoptera Collection of the Zoology Museum, Kiev State University and in the private collection of Dr. Eugene S. Miljanowski (Sukhumi, Georgia) who spent more than 30 years collecting in different parts of Abkhazia. From these sources I found some interesting, heretofore undescribed forms of lycaenid butterflies, one of which is described here with some brief remarks.

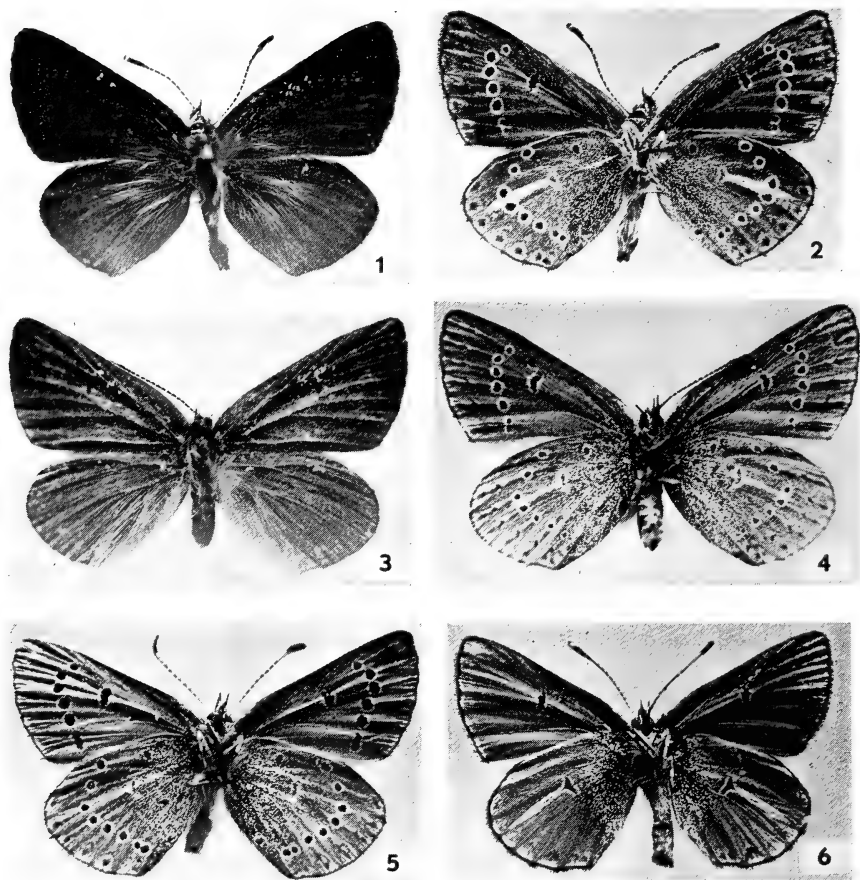
### ***Eumedonia eumedon modestus* Nekrutenko, new subspecies** (Figs. 1-6)

*Lycaena eumedon* Esp.: Romanoff, 1884, p. 52.

*Lycaena eumedon* Esp.: Wojtusiak & Niesiolowski, 1947, p. 58-59.

*Lycaena teberdina* Tschetv.: Miljanowski, 1964, p. 114.

**Male.** Length of the forewing (base to tip) of the holotype 14.0 mm (variation in type series 13.0 to 14.5 mm). Upperside of both wings of dark black-brown ground color, discal spots hardly recognizable. Underside ground color steel-grey,



Figs. 1-6. *Eumedonia eumedon modestus* n. subsp.: 1, 2, holotype, ♂, upper and undersides, S.W. Caucasus, Awadhara, 1800 m, 7-12 June 1971, Y. P. Nekrutenko; 3, 4, allotype, ♀, upper and under sides, same label data; 5, paratype, ♂, ab. *fylgia* Spangh., underside, same label data; 6, paratype, ♂, ab. *speveri* Husz., underside, same label data.

discal spot and series of postdiscal spots complete, surrounded with remarkable white rings. The white stripe on the underside of the hindwing is well developed, but is twice as narrow as that in European specimens. Blue powdered area on the underside of hindwing is relatively larger than in European specimens, and occupies about  $\frac{1}{3}$  of the entire wing surface. The main differential characteristic of the described subspecies is an extreme reduction of submarginal markings. Orange and black submarginal spots are almost absent on the underside of the forewing, and on the hindwing underside they are diffused, reduced and incomplete.

There are no essential differences from European specimens in the male genitalic structures except for a deeper incision between valval lobes.

**Male.** Length of the forewing of allotype 15.5 mm (14.9-15.9 mm). In size



Fig. 7. *Eumedonia eumedon modestus* n. subsp., type locality. A meadow below upper timberline at an elevation of 1800–2000 m at Awadhara, S. W. Caucasus, surrounded by endemic fir-trees *Abies nordmanniana* (Stev.) Spach.

and outer appearance very similar to male. This weak sexual dimorphism may often be confusing, especially in the field. However, in some females (including allotype) upperside of hindwing bears a hardly recognizable brown spot within anal angle. Underside pattern is quite similar to that of a male.

**Types.** Holotype, male, and allotype, female, S. W. Caucasus, Abkhassian Autonomous Soviet Socialist Republic, Awadhara, 1800–2000 m, 7–12 June 1971, Y. Nekrutenko (In Zool. Mus. Kiev Univ.). Paratypes 8 ♂♂, 2 ♀♀, same locality, dates and collector (In Zool. Mus. Kiev Univ.). Nine paratypes from Awadhara, June, July 1961, 1968 and 1969 (in coll. E. Miljanowski). 5 ♂♂ paratypes, Teberda, N. W. Caucasus, Mt. Chatipara, 2200–2400 m, 30 July to 6 August 1933, L. Sheljuzhko (Zool. Mus. Kiev Univ.). ♂ paratype, Teberda, N. W. Caucasus, Valley of the Teverda River, L. Sheljuzhko (Zool. Mus. Kiev Univ.), ♀ paratype, Teberda, Mt. Chatipara, 2600 m, 30 July 1933 L. Sheljuzhko (Zool. Mus. Kiev Univ.). ♂ paratype, Lebarde, W. Georgia, 3 July 1962 (coll. E. Miljanowski). 2 ♂♂, paratypes, Lagodekhi Reservation 25 July and 2 August 1959 (coll. E. Miljanowski). 3 ♂♂ paratypes, Yelizavetpol (now Kirovabad), Azerbaijan, 20 and 26 June (no year), A. Kashtshenko (Zool. Mus. Kiev Univ.). ♂ paratype, Bakuriani, Mt. Kochta, 31 July 1932, B. Tkatchukov (Zool. Mus. Kiev Univ.).

**Type locality** (Fig. 7). Because most specimens examined were collected in Awadhara, it is designated as the type locality of the described subspecies. Awadhara is a part of Ritsa Nature Reservation (Ritsinskiy Zapovednik) and lies 16 km up along the Lashipse River from Lake Ritsa, at elevation 1650–2500 m. *E. eumedon modestus* flies in rich meadows below and above upper timber line. The flight period extends from early June to early October (Miljanowski, personal communication).

Subspecific characters given above are stable for all specimens of *E. eumedon* Esp. ever seen from the Caucasus range. N. M. Romanoff (1854) reported the occurrence of *Lycaena eumedon* from 8 points in Transcaucasia, including Bakuriani, "en général sur les lieux élevés en Juillet." A male specimen from this locality, included in the type series, showed the appearance of the described subspecies in Caucasus Minor also. Wojtusiak & Niesiolowski (1947), who reported the occurrence of *E. eumedon* in the Central Caucasus (Karaugom, 1800-2500 m), have noted its smaller size, as compared to European specimens, and the "underside of wings not brown but grey." *E. eumedon* has not been included in the faunistic list of E. Miljanowski (1964) as it has been confused with *Lycaena teberdina* Shel. The latter is highly local in its occurrence (Teberda, N. W. Caucasus) and seems not to occur on the Southern side of the Great Caucasus (Sheljuzhko, 1934).

#### ACKNOWLEDGMENTS

I wish to express appreciation to Dr. Eugene S. Miljanowski for an interesting and useful discussion, and to Dr. Theodore D. Sargent who edited and corrected the manuscript.

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WOJTUSIAK, R. J. & W. NIESIOLOWSKI. 1947. Lepidoptera of the Central Caucasus, collected during the Polish Alpine Expedition in 1935, with ecological and zoogeographical remarks. I. Macrolepidoptera. Prace Muzeum Przyrodniczego PAU 6: 1-74.

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#### NOTES ON THE LIFE HISTORY OF *EUGONOBAPTA NIVOSARIA* (GEOMETRIDAE)

In spite of the abundance of *Eugonobapta nivosaria* Guenee in many localities in the northeastern United States and eastern Canada, there apparently has been no published account of the early stages.

Success in discovering these early stages came only after several failures to keep the eggs alive over winter. That problem was finally solved by confining the females in paper lined containers, and then, after the eggs were deposited on the paper, placing them in a wooden box which was stored in a sheltered place outdoors. This box, however, was covered with snow during much of the winter.



The eggs are brick shaped and are deposited side-by-side in short, compact, precisely arranged rows. These eggs are similar in shape, size, and arrangement to those of *Deuteronomos magnarius* Guenee, except that they are in shorter rows. They are pearly white, very finely but rather sparsely pitted on the upper surface. They seem unusually large for so small a moth, and the number of eggs produced by one female is evidently small. The maximum that I have ever obtained from one female is about 20.

The newly hatched larvae are translucent, almost colorless, very slender and very active. It is probable that they are quite general feeders on deciduous trees and shrubs, for I reared them on both choke cherry (*Prunus virginiana*) and red-osier dogwood (*Cornus stolonifera*). They soon became green, and grew very rapidly, the first one starting its cocoon just 15 days after hatching.

The mature larva is light green with inconspicuous yellowish subdorsal and lateral lines, and somewhat wider stigmatal stripes of the same yellow color. It is essentially smooth, but with slightly raised flat tubercles accompanying each abdominal spiracle. It is easy to understand why these larvae have been completely overlooked, since their feeding period is quite brief, and occurs at a time when the superficially similar appearing larvae of *Paleacrita vernata* Peck are likely to be numerous.

The pupa is delicate pale green, and is enclosed in a neatly woven, thin, but very tough cocoon of white silk spun among leaves. The most remarkable feature of the pupa is a complete set of conspicuous spiracular tubercles, quite unlike anything I have observed elsewhere. In the absence of the dorsal groove, the very weak development of the lateral grooves, the general arrangement of the cremaster hooks, the very light chitinization of the pupal skin, and the density of the cocoon, there are marked resemblances to pupae of the *Ennomos* group.

In the past it has been a problem to determine what the closest relatives of *Eugonobapta* may be, since the adults have evidently lost most of the structural features that might indicate relationship, and the early stages were unknown. In the light of what we now know, it seems very reasonable to believe that *Eugonobapta* is a perfectly good member of the *Ennomos* complex.

LAURENCE R. RUPERT, *Sardinia, New York 14134.*

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## CARDIAC GLYCOSIDES IN ASCLEPIAS SPECIES

Since the publication of my previous note (Slansky 1971, J. Lepid. Soc. 25:294) Jackson Bees has brought to my attention one publication (Masler et al. 1962, Collection Czechosl. Chem. Commun. 27:872-895) and others have appeared (Duffey 1970, Science 169:78-79; Duffey & Scudder 1972, J. Insect Physiol. 18:63-78; Feir & Suen 1971, Ann. Entomol. Soc. Amer. 64:1173-1174; Singh & Rastogi 1970, Phytochem. 9:315-331) reporting the presence of cardiac glycosides in *Asclepias syriaca* and other *Asclepias* species indicated by Brower (1969, Sci. Amer. 220:22-30) to lack these compounds, as cited in my prior note.

Perhaps, as pointed out by Duffey (op. cit.), the concentration of cardenolides in these *Asclepias* species is below a threshold level and/or these species lack cardenolides with strong emetic properties, such that monarchs, *Danaus plexippus* L., whose larvae feed upon these plants are palatable to predators, as found by Brower (op. cit.).

FRANK SLANSKY, JR., *Department of Entomology, Cornell University, Ithaca, New York 14850.*

## THE OCCURRENCE OF *CHLOROCLYSTIS RECTANGULATA* (L.) IN NORTH AMERICA (GEOMETRIDAE)

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While collecting moths in Nova Scotia in the summer of 1970 in company with Mr. Barry Wright of the Nova Scotia Museum, I was surprised to find a species with the habitus of *Eupithecia* Curtis but marked very obviously with bright green scaling on both wings and body. In more than 20 years of intensive field work in that area I had never seen such a moth, yet on this occasion collected nine specimens in three localities, separated by as much as 175 air miles.

A careful check on the identity of these specimens at the U.S. National Museum showed that they undoubtedly represent an Old World species, *Chloroclystis rectangulata* (Linnaeus), in the subfamily Larentiinae. The genitalia are very distinctive in both sexes and have been figured by various authors, including Pierce (1914, pl. 32), Juul (1948, pl. 13), and Nordström *et al.* (1940, text fig. 330, female). The Nova Scotian specimens agree with European ones in every detail, and both the normal and dark ("*nigrosericeata*") color forms are present. Colored figures of the adults may be found in many European works, and figures of the larvae are given by Juul (1948, pl. 3, fig. 27) and Nordström *et al.* (1940, pl. 40, fig. 21 l). This species will in any event be easily recognized because it is the only known representative of the genus *Chloroclystis* Hübner in the New World. In addition to the green markings, which do not readily fade, *Chloroclystis* differs from *Eupithecia* in rather obvious genital characters such as the obsolescence of the uncus, and the peculiar, forceps-like terminal armature of the aedoeagus. The female of *rectangulata* has two separate, crescent-shaped signa on opposite sides of the bursa copulatrix.

It should be noted that one of the commoner species of *Eupithecia* of the eastern United States, *E. miserulata* Grote, also may have quite conspicuous green scales on the wings when very fresh. However, the green coloring in this species is no longer apparent in museum specimens more than one or two years old, having faded to yellowish brown. The genitalia of *miserulata* were figured by McDunnough (1949, fig. 4A). I know of no other North American species with which *C. rectangulata* is likely to be confused.

*Chloroclystis rectangulata* is very widespread and common in Europe, occurring even north of the Gulf of Bothnia. The main host plants are

reported to be *Crataegus*, *Prunus* and *Pyrus*, and Prout (1915: 299) stated that the larva feeds in the blossoms of wild and cultivated apple and is often very injurious. It has also been mentioned as a pest of pear (Meyrick, 1927: 218) and quince (Dirimanoff *et al.*, 1961). Harrison (1953) reported finding it on blackthorn (*Prunus spinosa*) in England, but noted that for the most part it seems restricted to orchards. The eggs hibernate and the larvae mature rapidly in the spring.

The Nova Scotian records for this species are as follows: Smiley Brook Provincial Park, near Brooklyn, Hants Co., July 20, 1970 (1); Middle River, Victoria Co., Cape Breton Island, July 27, 1970 (6); Baddeck River, near Baddeck Bridge, Victoria Co., July 29, 1970 (2)<sup>1</sup>. All were taken at light in moist bottomland situations. *Crataegus* spp. and *Prunus virginiana* L., possible host plants, were common to all three localities. The specimens are in the collections of the Nova Scotia Museum, Halifax, and the United States National Museum.

The sudden appearance of such a conspicuously different moth, in a region where the Geometridae had been investigated intensively over a period of many years, leaves little doubt that this represents a quite recent introduction. However, its presence both on the mainland of Nova Scotia and on Cape Breton Island, in localities so far apart, indicates a well established population.

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<sup>1</sup> Another specimen, a fresh female, was collected at the Hants Co. locality on 23 July 1972, indicating the continued presence of the species.

NEW RECORDS OF LEPIDOPTERA FROM THE UNITED STATES  
(ARCTIIDAE, GEOMETRIDAE, EPIPLEMIDAE)

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Collections of moths that I have recently examined from various sources included five species hitherto unreported from the continental United States, or indeed from anywhere in America north of Mexico. One of these is an especially interesting species described from Siberia; the others are of neotropical distribution. Their occurrence in this country is believed to be natural, not a result of introduction by man. They are as follows.

## Arctiidae

*Hyperborea czekanowskii* Grum-Grshimailo*Hyperborea czekanowskii* Grum-Grshimailo, 1900: 464.*Phragmatobia czecanousci* Hampson, 1920: 349-350.

One male specimen of this species (Fig. 1) was collected on the Seward Peninsula of Alaska and sent to me for identification by Dr. Kenelm W. Philip of Fairbanks, who recognized it as something unusual. It bears the following data: Grassy delta near mouth of Serpentine River 20 mi. SE of Shishmaref, Seward Peninsula, Alaska, 25 June 1970, W. Foster. I had expected that this would prove to be an undescribed species, but found that it so closely matches the description and figure of *H. czekanowskii* in Seitz (1910: 103, pl. 18h) that there can be little doubt as to its identity. Seitz gave for its distribution only the Tunguska River [in central Siberia], but I found on consulting the original description that the type series consisted of 17 males and one female for which were given the following data: Valley of the lower Tunguska River, 1873; valley of the Olenek River between the lower Tomba and the Alakit, July, 1874; valley of the Adytscha [Adycha] River at its confluence with the Jana [Yana], July 3-4, 1885. The spellings in brackets are as given on recent National Geographic Society maps. The Adycha River locality is closest to Alaska, being about 1,700 miles west of the Seward Peninsula and slightly farther north.

*H. czekanowskii* is the monobasic type-species of the genus *Hyperborea*, which Grum-Grshimailo proposed for his new species in the same paper. Although it has very much the appearance of an *Apantesis* species, the antennae are peculiar, appearing nearly simple on comparison with the bipectinate male antennae of all known species of the genus *Apantesis*

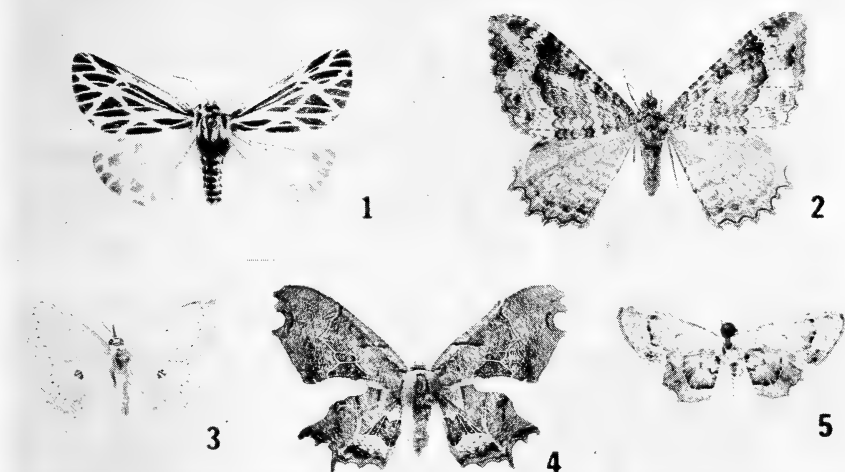


FIG. 1-5. 1, *Hyperborea czekanowskii* ♂, Seward Peninsula, Alaska (full data in text); 2, *Triphosa affirmata* ♀, Guatemala; 3, *Semaeopus cantona*, holotype ♂, Orizaba, Mexico; 4, *Erosia incendiata* ♀, Kingsville, Texas, 15 November 1968, J. E. Gillaspay; 5, *Antiplecta triangularis* ♀, Brownsville, Texas (full data in text). (Figs. 1-4 natural size; Fig. 5 twice natural size.) Photographs made by photographic laboratory of National Museum of Natural History, Smithsonian Institution.

Walker. The male antennae of *czekanowskii* are slender but biserrate, with a large bristle arising from the end of each process, and with the shaft setose ventrally and quite heavily scaled dorsally. The eyes are reduced, as would be expected of an arctic species with diurnal flight habits. The body is more slender than is usual in *Apantesis*, although not as slender as it appears in Seitz's figure, and the hindwings are somewhat subhyaline. The moth is rather colorless compared to most species of this group; the forewing is blackish, traversed with pale lines as in *Apantesis*; the hindwing is dull whitish with dark gray-brown spots, and the abdomen is banded with the same shades except for a small caudal tuft of yellow hair. In the region where it occurs, *czekanowskii* is likely to be confused only with *Apantesis quenseli* (Paykull), or possibly with *A. turbans* (Christof), both however stouter-bodied, differently marked species with pectinate male antennae. Also, *czekanowskii* is unlike any species of *Apantesis* in our fauna in having two strongly oblique pale lines meeting the inner margin of the forewing. Although I suspect that this species may fit just as well in the genus *Apantesis*, I leave it for the present as originally proposed. As the Alaskan specimen is the only one

available, I prefer not to remove the abdomen for genital dissection until it has been figured in color for *The Moths of America North of Mexico*.

Hampson (1920: 349) placed this species in the genus *Phragmatobia*, but it does not appear at all closely related to the group that includes the type-species, *Phragmatobia fuliginosa* (L.). Hampson also changed the spelling of the species name to *czecanousci*, this being an unjustified emendation which is a junior objective synonym of the name in its original form.

### Geometridae

#### *Semaeopus cantona* (Schaus)

*Cnemodes cantona* Schaus, 1901: 192.

*Semaeopus cantona* Prout, 1936: 88, pl. 11e.

Several specimens of this species were collected in the Santa Ana Wildlife Refuge, Hidalgo, Texas by Mr. and Mrs. André Blanchard. The specimen that I examined was a male, taken 20 October 1970, and it appeared to agree exactly with the type in the collection of the U.S. National Museum from Orizaba, Mexico (Fig. 3). The Texas specimens are all in the Blanchard collection.

#### *Triphosa affirmata* (Guenée), new combination.

*Scotosia affirmata* Guenée, 1857: 447, pl. 9, fig. 2 (not *affirmaria* Walker, 1860).

I identified and returned to Mr. Charles P. Kimball a very rubbed female of this species taken at Homestead, Florida, 29 March 1969 (C. E. Hallas collection). It is a neotropical species described from Brazil but known from Mexico to Argentina. The specimen illustrated (Fig. 2) is from Guatemala.

### Epiplemidae

#### *Erosia incendiata* Guenée

*Erosia incendiata* Guenée, 1857: 35, pl. 8, fig. 4.

A female of this species in very nearly perfect condition was found resting on the brick wall of the Department of Biology building at Texas A & I University, Kingsville, Texas, on 15 November 1968, and kindly donated to the U.S. National Museum by the collector, Dr. J. E. Gillaspay. The species is widespread in the neotropics from southern Mexico, including Yucatan, to French Guiana and Brazil. There is a good series in the U.S. National Museum mostly from Jalapa, Orizaba and Cordova, Mexico, Costa Rica and French Guiana. It was described from Brazil. The species is sexually dimorphic, which will help to explain the dif-

ference between the Texas specimen (Fig. 4) and the male figured by Guenée. The red coloring on the hindwing in Guenée's illustration is greatly exaggerated.

*Antiplecta triangularis* Warren

*Antiplecta triangularis* Warren, 1906: 401.

A single poor specimen in the collection of the United States National Museum taken at Brownsville, Texas, "March 27: 28," at light, F. H. Benjamin (Fig. 5), appears to agree exactly with the type material of this species from Orizaba, Mexico, also in the U.S. National Museum. Benjamin had tentatively identified it, but as far as I know the record was never published. The specimen is a female. A closely related but obviously different species of *Antiplecta* occurs in southern Florida, and this one is probably undescribed. An example loaned to me for study by Mr. Charles P. Kimball was taken on Key Largo, 20 July 1962.

After this paper was submitted, I found additional material of *Antiplecta triangularis* in the collection of Mr. André Blanchard at Houston. A series of fresh specimens of both sexes was taken at the Santa Ana Refuge, Hidalgo Co., Texas, 14 November 1971.

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POPULATION EXPANSIONS AND MASS MOVEMENTS OF  
*NYMPHALIS CALIFORNICA* (NYMPHALIDAE)

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Mass movements by California tortoise shell butterflies have been sporadically recorded during the past 115 years in widespread parts of the Pacific Coast states. The flights, which follow massive population increases in relatively localized areas, have been called migrations in the literature (e.g. Williams, 1930, 1938).

After about a decade of comparative stability, *N. californica* has again disrupted its equilibrium, and its swarms became conspicuous during 1971. According to an Associated Press release dated 11 August, which was published in various parts of the country, butterflies "by the millions" were flying in the vicinity of Mt. Shasta, Siskiyou County, California, "slickening the highways" in the towns of Mt. Shasta, Dunsmuir, and McCloud (see *Lepid. News*, 1971, No. 5).

Truck drivers were quoted as saying they could go only 25 miles per hour owing to the dense clouds of butterflies which crossed the highways. The report stated that the butterflies began appearing in hordes about five weeks previously [in early July]. Local naturalists reported that the flights consisted of six nymphalid and one lycaenid species (three of which do not occur in northern California), but the roster did not include *N. californica*. That swarms did consist of the latter species, however, is indicated by several lines of evidence: a) correspondence to the editor of *Lepidopterists' News* by five observers during the fall of 1971 agreed that this was the dominant species (*Lepid. News*, 1971 No. 6:1); b) R. Lyon (Pacific Southwest Forest and Range Experiment Station, Berkeley), who witnessed the flight on 6 August, reported (*in litt.*) that the butterflies appeared to be all one species and that it was identified as *Nymphalis californica* by R. Hill (formerly of the Pacific SW Forest and Range Expt. Sta., now retired). Hill made an on-site detection report to the Forest Service; c) J. Helfer (1971, *The Mendocino Beacon*, 20 Aug. 1971, p. 4) reported that the flights were observed by J. Myers who had just returned from Mt. Shasta, bringing a specimen which Helfer identified as *N. californica*.

From all reports the flight structure and timing are strikingly similar to those which I observed in 1958 when I lived at Mt. Shasta all summer. That season the butterflies appeared in large numbers on the mountain



slopes at 4,000–6,000 feet during 22–26 June, but were not seen to emigrate (snowline was then below 7,000 feet). Then during 3–7 August, a brood of fresh individuals appeared in tremendous numbers at 6,000 to 8,000 feet and moved outward to subtending areas. I observed them in aggregations at damp soil in the town of Mt. Shasta and as far as three miles northeast of Weed (6 SW and 6 NW airline miles from the colonies observed on the mountain). The three towns mentioned in the AP release above are approximately 6 SW, 11 SSW, and 8 SSE airline miles from timberline, respectively, so that it seems probable that dispersal occurs in all directions into the 2,000–3,000 ft. elevation valleys which surround the 14,000 ft. mountain.

How distant these flights extend is unknown, but in October 1971, mass flights were noted in two other parts of California where *N. californica* does not commonly occur in high numerical density, east of the Sierra Nevada in Mono County and in the San Francisco Bay area. These places are approximately 300 SE and 250 SW airline miles from Mt. Shasta. At Highway 395 near Mammoth Lakes, E. Kane (State Department of Agriculture, Sacramento) (*in litt.*) counted 173 *N. californica* flying easterly during a five minute period at about 1530 on 8 October. In the Berkeley Hills near San Francisco Bay the butterflies were flying southeastward, along the axis of the hill ridge, at rates of 1.5 to 11/minute on a 50-foot sighting line during midday on 5, 7, and 12 October and were absent on 14 and 28 October (Powell, 1972). Moreover, circumstances indicate that sightings reported by Arnaud (1972, in: Proc. Pacific Coast Entomol. Soc. 341st meeting, Pan-Pacific Entomol. 48: 72) at a height of 600 feet in downtown San Francisco on 4–5 October, also involved *N. californica*.

The last time that an outbreak occurred in the San Francisco Bay area was in 1959–1960, when moderate aggregations were followed in the second season by tremendous numbers of the adults in June in Marin County. Various personal communication and literature reports which I have accumulated in addition to those summarized by Williams (1930, 1938) show that the outbreaks are recurrent, especially at Mt. Shasta, where there are reports of the swarms for 1889, 1902, 1911, 1926, 1931, 1932, 1952, 1958, and 1971. Most likely the phenomenon occurred in other years as well but was not reported, such as during the 1918–1922 and 1941–1944 eras, judging from records at other localities. In any case, it appears that localized defoliation of *Ceanothus*, the preferred host plant, and mass movements of the butterflies occur at intervals of around 5–13 years but too irregularly to allow precise prediction of any cyclic periodicity.

Recorded outbreaks at secondary areas, such as Marin County in 1959-1960, apparently have resulted from preceding emigration from Mt. Shasta or other epidemic centers and have masked generalizations concerning possible periodic phenomena which may have obtained.

The records suggest that this species periodically develops an imbalance with factors in its population equilibrium at isolated sites, followed by mass emigration of adults in various directions, and sometimes subsequent colonization and population explosions in secondary districts in the first or second following year. The populations then return to low density numbers or may disappear altogether in outlying colonies. Thus, *Nymphalis californica* should not be considered a migratory species except in the broadest sense.

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#### TWO NAME CHANGES FOR SUBTROPICAL AMERICAN PIERIDAE

On a recent visit to Oxford I had an opportunity to examine the collection of unpublished drawings known to early authors as "Jones's Icones." Many of these drawings, and probably the specimens upon which they were based, were used by Fabricius. Some time ago it had been suggested to me that the current interpretation of *castalia* Fabricius, 1793, is grossly incorrect. This is one of the names based upon a Jones figure. Upon examining the plate in question at Oxford I found that it is a clear representation of what today is called *Appias drusilla* (Cramer), [1777]. Therefore, *Papilio castalia* Fabricius, 1793, is a synonym of *Papilio drusilla* Cramer, 1777.

There are several recognized subspecies of *drusilla*. Jones's figure is based upon a Jamaican specimen and represents the subspecies named *jacksoni* Kaye, 1920. This name must yield to the earlier Fabrician name. The Jamaican subspecies must be called *Appias drusilla castalia* (Fabricius), 1793.

Transfer of the name *castalia* from *Kricogonia* to *Appias* requires recognition of *lyside* Godart, 1819, as the specific name for West Indian *Kricogonia*. Although dos Passos in his Synonymic List . . . recognized two species in the genus, *castalia* and *lyside*, Mr. Thomas Turner has demonstrated through breeding experiments that the two develop from eggs laid by a single female. Therefore only one species is involved. Its name is *Kricogonia lyside* (Godart). Haiti probably is the type locality for *lyside*.

OBSERVATIONS AND NEW RECORDS  
OF IOWA RHOPALOCERA

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Our knowledge of the Lepidoptera of Iowa has suffered in recent years from minimal collecting and a resultant scarcity of published information. With the exception of a short paper by Miller (1961), Christenson's (1971) recent work is the first significant study of the state's butterfly fauna to appear in nearly fifty years. Encouraged through communication with Christenson and by the accessibility of available data, I decided to make a personal survey of Iowa butterfly populations in the vicinity of Iowa City (Johnson County) during a short period of residence in the state in 1971.

The more fragile elements of Iowa's native flora and fauna have suffered profoundly from the extensive commercial modification the state has experienced during the last fifty years. Thus I was interested in examining the few areas which had escaped the plow and were relictual associations of flora which predominated in the state prior to the advent of cultivation.

Christenson (1971) mentions 22 species of butterflies that have not been collected in Iowa since 1920, but were recorded prior to that time. I was eager to investigate the possibility that some of those species survived the drastic modification of the Iowa landscape and continued to maintain populations in the biotic refugia of the area. These areas might be expected to support populations of species of limited distribution in Iowa, owing to plant associations and other biotic requirements which only such isolated refugia could provide. Of the 130 species of butterflies known to occur in Iowa, 19 had been recorded from one county only (Christenson, 1971). Though 10 species appear to reach their distributional limits within the state (op. cit.), which might partially account for some of the single-county records, this fact also suggested the importance of examining the fauna of plant communities which had previously been overlooked. The recent state records of Miller (1961) also seemed to support this notion.

Several localities in Johnson County were selected which appeared to meet these considerations and, due to their proximity to my home, could be visited on a regular basis throughout the season: Williams Prairie, a small private preserve about 4 miles north of Oxford; the vicinity of

Cou Falls (the northeast corner of the 13,000-acre Hawkeye Wildlife Area which surrounds the Coralville Reservoir west of Highway 218); MacBride Field Campus of the University of Iowa, about 4 miles north of North Liberty; and the area to the southeast of the Field Campus and north of the Coralville Reservoir known as Sugar Bottoms. These localities were visited at least bi-weekly for the three-month period 20 April–20 July, following which other considerations were responsible for terminating my investigations. In addition, Muskrat Slough, a public hunting access owned and maintained by the State Conservation Commission and located approximately 7 miles north-northeast of Mechanicsville in Jones County, was visited on two occasions in July, and one trip was made to the Paint Creek Unit of the Yellow River State Forest, near Waukon Junction in Allamakee County, on 10–11 July.

Of the areas selected, Muskrat Slough is a typical marshland situation. Cou Falls, MacBride Field Campus, Sugar Bottoms and Yellow River State Forest are, in general, representative of the deciduous oak-hickory woodland bordering most of the state's major rivers. Virgin prairie, once the characteristic feature of the Iowa landscape, has succumbed nearly *in toto* to extensive cultivation and exists today essentially as four state-owned preserves and a few private holdings. Williams Prairie is representative of what little remains of these fascinating ecological communities. The flora of these areas has been described by Conard (1958).

Following is a descriptive list of the more significant records and observations. Included are 35 new county records representing 31 species, 5 of which had previously been reported from one or two counties only. In addition there are new records of all four species recently reported as new to the state by Miller (1961). Though I failed to discover populations of any of the 22 species which have not been collected in the state since 1920, 7 species were taken for which only one or two recent records exist. It is my hope that some of the observations which follow will serve to stimulate future investigations of Iowa's butterfly fauna, especially in view of the continuing threat of additional commercial exploitation.

#### HESPERIIDAE

*Euphyes dion* (Edwards). 5, 13 July 1971, Muskrat Slough, Jones Co. (5 ♂♂). This species was first credited to the Iowa fauna by Miller (1961), who took specimens at Pilot Knob State Park and a swamp near Klemme, both Hancock County, on 22 July 1960. With the exception of a few specimens in a display collection at the University of Iowa labelled "Banner area, Warren County" and bearing dates in the mid-1960s, the present series is the first taken since that time. New county record.

*Euphyes conspicua* (Edwards). 28 June, 1, 20 July 1971, Williams Prairie, Johnson

Co. (13 ♂♂, 4 ♀♀); 5, 13 July 1971, Muskrat Slough, Jones Co. (4 ♂♂, 1 ♀). New county records.

*Euphyes bimacula* (Grote & Robinson). 19, 21, 23, 28 June, 1 July 1971, Williams Prairie (10 ♂♂, 6 ♀♀). New county record.

It should be noted that *E. dion* appears to be absent from the Williams Prairie fauna. On several occasions during July, when the species was flying at Muskrat Slough, an intensive search of the area failed to produce specimens. In conjunction with the need to determine whether *E. bimacula* occurs at Muskrat Slough (my first visit to the area was made at the terminus of the species flight), this observation provides excellent opportunity for subsequent investigations of host-plant specificity and biotic studies in general of these poorly-known hesperiids.

*Poanes viator* (Edwards). 5 July 1971, Muskrat Slough, Jones Co. (1 ♀). All previous records of this species have been from Pilot Knob State Park, Hancock County, where Miller (1961) first discovered it in Iowa on 22 July 1960. New county record.

*Polites origines* (Fabricius). 23 June 1971, MacBride Field Campus, Johnson Co. (1 ♂). Christenson (1971) mentions the rarity of this species in Iowa. New county record.

*Polites mystic* (Edwards). 19, 21 June 1971, Williams Prairie, Johnson Co. (7 ♂♂, 6 ♀♀). *P. mystic* seems to be very locally distributed throughout Iowa. This previously unrecorded population is of some interest due to the extent of variation apparent in the series. Specimens run as dark in the ground color of the ventral hindwing as typical eastern *mystic* to even lighter than the norm of the prairie subspecies *dacotah* (Edwards). Specimens collected farther west in Dallas County by Miller (in litt.) seem referable to *dacotah*. Other Iowa populations should be closely examined to determine the extent of this blend zone. New county record.

#### LYCAENIDAE

*Harkenclenus titus* (Fabricius). 28 June, 1 July 1971, Williams Prairie, Johnson Co. (6 ♂♂, 1 ♀); 3 July 1971, Cou Falls, Johnson Co. (1 ♂); 11 July 1971, Yellow River State Forest, Allamakee Co. (2 ♀♀). An unusually abundant species in 1971. New county records.

*Satyrum liparops strigosa* (Harris). 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♀). One of three recent captures. New county record.

*Satyrum acadica* (Edwards). 1 July 1971, Williams Prairie, Johnson Co. (1 ♂). With the exception of three specimens in a display collection at the University of Iowa taken at Sheeder Prairie, Guthrie County, on 23 June 1965, the present record is the first for the species in recent years. New county record.

*Callophrys (Incisalia) henrici* (Grote & Robinson). 22, 23, 24 April 1971, Sugar Bottoms, Johnson Co. (2 ♂♂, 1 ♀). Prior to my discovery of this species in Johnson County it had been recorded only from Fremont and Pottawattamie Counties in the extreme southwestern corner of the state. Christenson (1971) implies that the paucity of records in Iowa may be due to the absence of redbud (*Cercis canadensis* Linnaeus), a commonly-mentioned host, from most areas of the state. This plant does not occur in the Sugar Bottoms area. *Prunus*, however, also mentioned as a host, is abundant there. New county record.

*Callophrys (Mitoura) gryneus* (Hübner). 22 April 1971, Sugar Bottoms, Johnson Co. (1 ♂, 1 ♀); 23, 25 April, 8 May, 14 July 1971, 2 miles west of Cou Falls, Johnson Co. (14 ♂♂, 6 ♀♀). Previously recorded only from Henry and Linn Counties, I found *C. gryneus* to be fairly abundant at both locales where I discovered it in Johnson County, though restricted to the immediate vicinity of its foodplant, *Juniperus virginiana* Linnaeus (red cedar). It was also observed, though not collected, at Effigy Mounds National Monument, Allamakee County, on 11 July 1971. Further collecting should prove the species to be much more widely distributed in Iowa than the records indicate. New county record.

*Panthiades m-album* (Boisduval & LeConte). 3 May 1971, Cou Falls, Johnson Co. (1 ♂). Miller (1961) took a single female of this species at Waubonsie State Park, Fremont County (extreme southwest Iowa), on 22 May 1960, thus discovering it for the first time in Iowa. The fact that the present specimen, the second recorded from the state, was taken in fresh condition at the same time of year seems to indicate that *P. m-album* very likely breeds in Iowa, if only sporadically. Miller (in litt.) is of the opinion that the species probably occurs in small, very local populations throughout at least the southern half of the state. New county record.

*Lycaena thoe* Guérin-Ménéville. 28 May, 5, 12, 19, 21, 23 June 1971, Williams Prairie, Johnson Co. (11 ♂♂, 5 ♀♀).

*Lycaena xanthoides dione* Scudder. 19, 21, 23, 28 June, 1 July 1971, Williams Prairie, Johnson Co. (11 ♂♂, 9 ♀♀).

*Lycaena helloides* (Boisduval). 28, 29 May, 5 June, 1 July 1971, Williams Prairie, Johnson Co. (15 ♂♂, 12 ♀♀).

*Lycaena phlaeas americana* Harris. 28 May, 23 June 1971, Williams Prairie, Johnson Co. (11 ♂♂, 7 ♀♀). Two of the 11 males collected at this locality are of the aberrant phenotype "*fasciata*" (Strecker).

Mention is made of the occurrence at a single locale of all four species of *Lycaena* native to the state in light of the unusual nature of this observation. There are probably very few spots in Iowa where this situation exists. There are records for each of the four species from Story County (Christenson, 1971), though it is not known whether there is any area in the county where the populations occur sympatrically. Data on host-plant specificity for each of the species at Williams Prairie would be of great interest, as well as observations on the territorial aspects of courtship and mating.

## SATYRIDAE

*Lethe eurydice fumosa* (Leussler). 19, 21, 23 June 1971, Williams Prairie, Johnson Co. (20 ♂♂, 3 ♀♀); 5 July 1971, Muskrat Slough, Jones Co. (4 ♂♂, 1 ♀). Special notice is given the present records of *L. e. fumosa* in light of the recent treatment of the *Lethe eurydice* complex by Cardé *et al.* (1970). This subspecies appears to be restricted to "small, isolated colonies (many now extinct) in sedge, permanent marshes in the prairie regions from Minnesota and South Dakota to Indiana, Nebraska and Colorado" (op. cit.). The early stages of *fumosa* are unknown, and the discovery of two large populations of the subspecies in eastern Iowa should increase the feasibility of subsequent investigations of the biology of this insect. Miller (in litt.) has seen typical *eurydice* from northern Iowa, but does not have the exact locality. Collectors should also be aware of the possible occurrence of *Lethe appalachia* R. L. Chermock within at least the eastern third of the state. New Jones County record.

*Cercyonis pegala* (Fabricius). 28 June, 1 July 1971, Williams Prairie, Johnson Co. (15 ♂♂). Emmel (1969) states in his discussion of *C. pegala* that the *alope* (Fabricius) phenotype "ranges from Virginia and New Jersey north to eastern Quebec and Maine," and indicates that to the north and west of this area it intergrades with the *nephele* (Kirby) phenotype, which evidences none of the yellow forewing patch of *alope*. One would expect Iowa populations to be predominantly of the *nephele* phenotype and, indeed, most records from the state refer to this morph. It was with some surprise, then, that of the 15 males taken at Williams Prairie two display the conspicuously yellow-patched forewing of *alope*. All 13 additional specimens taken at Williams Prairie and those collected at other localities in Iowa during 1971 are typical *nephele*. Miller (in litt.) has occasionally taken *alope*-like females further west in Polk and Dallas Counties, but has seen no males from those areas with a yellow-patched forewing. Further collecting may uncover other morphic populations of *C. pegala* in Iowa.

## Additional New County Records

## HESPERIIDAE

*Euphyes vestris metacomet* (Harris). 10, 16 June, 3 July 1971, Cou Falls, Johnson Co. (3 ♂♂); 11 July 1971, Yellow River State Forest, Allamakee Co. (2 ♀♀).

*Poanes hobomok* (Harris). 6, 9, 10, 15, 16 June 1971, Cou Falls, MacBride Field Campus, Johnson Co. (7 ♂♂, 3 ♀♀).

*Pompeius verna* (Edwards). 3 July 1971, Cou Falls, Johnson Co. (2 ♀♀).

*Wallengrenia otho egeremet* (Scudder). 14 July 1971, Cou Falls, Johnson Co. (1 ♂); 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♂).

*Polites themistocles* (Latreille). 28 May, 6, 9, 15 June 1971, Cou Falls, MacBride Field Campus, Williams Prairie, Johnson Co. (6 ♂♂, 1 ♀).

*Ancyloxypha numitor* (Fabricius). 9, 12, 19, 21 June 1971, MacBride Field Campus, Williams Prairie, Johnson Co. (4 ♂♂, 1 ♀).

*Erynnis brizo* (Boisduval & LeConte). 22, 23, 24 April, 3, 9 May 1971, Sugar Bottoms, Cou Falls, Johnson Co. (7 ♂♂, 6 ♀♀).

*Erynnis horatius* (Scudder & Burgess). 3 May 1971, Cou Falls, Johnson Co. (1 ♂). (det. H. A. Freeman).

*Epargyreus clarus* (Cramer). 9 May, 6, 9, 15, 16 June 1971, Cou Falls, MacBride Field Campus, Johnson Co. (5 ♂♂, 1 ♀).

## LYCAENIDAE

*Satyrrium calanus falacer* (Godart). 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♂).

*Strymon melinus humuli* (Harris). 3 July 1971, Cou Falls, Johnson Co. (1 ♂).

*Everes comyntas* (Godart). 23 April, 15 May, 9, 12 June 1971, Sugar Bottoms, MacBride Field Campus, Williams Prairie, Johnson Co. (4 ♂♂, 3 ♀♀).

*Celastrina argiolus pseudargiolus* (Boisduval & LeConte). 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♀).

## NYMPHALIDAE

*Chlosyne gorgone carlota* (Reakirt). 20, 27, 28, 29 May 1971, Cou Falls, Williams Prairie, Johnson Co. (5 ♂♂, 2 ♀♀).

*Boloria toddi ammiralis* (Hemming). 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♂).

*Speyeria cybele* (Fabricius). 11 July 1971, Yellow River State Forest, Allamakee Co. (2 ♂♂).

*Speyeria aphrodite alcestis* (Edwards). 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♂).

## SATYRIDAE

*Lethe anthedon* (Clark). 11 July 1971, Yellow River State Forest, Allamakee Co. (1 ♀).

## ACKNOWLEDGMENTS

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## SOME NOTES ON THE SPHINGIDAE

Since the appearance over a year ago of the first published part of the continuing work on the Moths of America (Hodges, R. W. in Dominick, R. B. *et al.*, 1971, *Moths of America North of Mexico*, fasc. 21, *Sphingoidea*), some additional information has been gathered by the author on this group in the area of McClellanville, South Carolina.

*Darapsa myron* (Cramer) is taken frequently at bait. We use fermented peaches or bananas, no extras added, with good results. It should be added that *myron* and *D. pholus* (Cramer) generally are not easy to differentiate in the traps, if only to emphasize the difficulties inherent in field identification.

*Darapsa versicolor* (Harris) occurs here somewhat later than stated in the reference, being taken at light in latter July and August, though we have only half a dozen specimens in the Wedge Plantation collection (WPC).

*Paonias astylus* (Drury) in this locality has two definite broods, the first in April, and the second in late July to early August. All WPC specimens to date have been taken at light.

*Sphinx franckii* Neumoegen. Four specimens have been taken. One on 8 June 1968, and three in 1971, dated 23 June, 14 August, and 1 September. All were ♂♂, and all came to light. This sudden 1971 take of three induced us to look for the foodplant, ash, so far without success. Either there is undiscovered ash nearby, or in this locality *franckii* has fixed on some other foodplant.

*Erinnyis obscura* (Fabricius), one ♂, 25 October 1968, to light.

*Deidamia inscripta* (Harris). Hodges notes that it flies just before sunrise. This information was taken from a note in the WPC collection which related to only two specimens that were actually seen by me to fly into one of our traps at that time. The collection, however contains not only several specimens flying at this time of day, but also a goodly number flying from roughly midnight on. It would therefore seem more accurate to say that it is a *late* flier. Both sexes have been taken at light (none at bait), and the larva has been reared on *Vitis* sp.

I should like to add at this point that the editors of *Moths of America North of Mexico* hope that such additional information as this will be published as available by various workers, for we fully realize that there is much still to be learned and much that collectors and institutions have already available which has not been assembled. Many life histories, distribution records, habits and other information of interest have been studied and recorded by individuals who have not published, with resulting gaps in the literature.

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## CONFIRMATION OF A DISPUTED FOODPLANT OF *PAPILIO GLAUCUS* (PAPILIONIDAE)

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Although reported as a polyphagous species, feeding on more than 13 families, 21 genera, and 34 species of plants, *Papilio glaucus* L. does appear to have different foodplant preferences in different regions over its range (Brower, 1958; Remington, 1968).

Because foodplant records in the literature are frequently suspect (Brower, 1958; Shields, Emmel, & Breedlove, 1970), I feel it important to verify a single, very early observation by Sir John Abbot, who recorded *P. glaucus* feeding on hop tree, *Ptelea trifoliata* (Rutaceae). This observation was made in Georgia and was reported in his manuscripts (Abbot, 1792–1804), which have been cited by Boisduval & LeConte (1833), D'Urban (1857) and Scudder (1889). I have been unable to find any other recorded observations of *P. glaucus* on *Ptelea*.

My observation was made on 5 July 1971, in the Cornell Plantations near Ithaca, New York. A very early second instar larva was found resting on a leaflet approximately six feet off the ground. This larva was taken back to the laboratory and reared for positive identification through all of its stadia on leaves from this plant. This wafer ash (hop tree) is in the open and is maintained as part of the Plantation.

Within the rest of the *P. glaucus* group, Kendall (1957, 1964) reported finding *Papilio multicaudatus* Kirby larvae on *Ptelea trifoliata* in Texas, confirming Behr's (1884) observation in California. Comstock (1927) reported *Ptelea baldwinii* as a foodplant for *Papilio rutulus* Boisduval in California. This hop tree has been incorrectly interpreted as 'hop' (*Humulus*) since that time (see Brower, 1958), and perhaps such confusion is responsible also for the rather unlikely records of *P. glaucus* feeding on *Humulus lupulus* (e.g. Scudder, 1889; Teitz, 1952). Possibly the 'ash,' *Fraxinus trifoliata*, referred to by Couper (1874) as a foodplant of *P. glaucus*, was also in reality the wafer ash, *Ptelea trifoliata*.

I feel that my observation of *P. glaucus* on Rutaceae is interesting from the standpoint of the 'synergistic co-evolution' of the Papilionidae and their foodplants (Slansky, in press). Unlike related smooth, green, eye-spotted larvae in Asia (*Papilio bianor* Cram. group) which feed on Rutaceae (Jordan, 1908), the *P. glaucus* group and the *Papilio troilus* L. group are both believed to have arisen in the New World and to have

fed originally on Lauraceae and Magnoliaceae before expanding their foodplant diets (Forbes, 1932, 1958; Munroe, 1960).

Having both the essential oils of the Umbelliferae and the alkaloids of the Aristolochiaceae and Magnoliales (including Magnoliaceae, Lauraceae, and Annonaceae), the Rutaceae seem to have played a key role in much of the co-evolution of the Papilionidae and their foodplants (Dethier, 1941; Ehrlich & Raven, 1965). Whether or not this *P. glaucus*-Rutaceae interaction is some relic from the phylogenetic past of *P. glaucus*, or a secondary consequence of its polyphagous habit, is unknown.

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THE BIOLOGY OF *CALLOPHRYS* (*INCISALIA*)  
*FOTIS BAYENSIS* (LYCAENIDAE)<sup>1</sup>

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Despite its occurrence in a region which has been explored by lepidopterists for over a century, *Callophrys* (*Incisalia*) *fotis bayensis* Brown was not discovered until 1962 (Brown, 1969a). At the present writing, the type locality of this unique butterfly, the San Bruno Mountains in San Mateo County, California, is about to be "developed" for homesites and commercial properties. Although efforts are being made by conservationists to halt this destruction of the natural habitat, it appears unlikely that the San Bruno Mountains will remain unaltered. For this reason, numerous visits have been made to this area over the past four years to record as much of the biology of the butterfly fauna as possible before it is permanently lost to science. Many of the data in this paper were gleaned during these investigations.

Brown (1969b) published a brief description of the larva and habitat of *C. f. bayensis*. Our purpose is to provide additional detailed information on the biology of the insect. Emmel carried out intensive field work in the San Bruno Mountains to document preferred habitat, flight span, and behavior of adults and immatures. Ova were sent to Ferris for rearing and describing of the immature stages. To determine the regional distributions of *bayensis*, Emmel surveyed the San Francisco Bay area from 1968 to 1971 to locate populations of *Callophrys fotis* outside of the type locality.

### Distribution

The San Bruno Mountains are located on the San Francisco Peninsula at the northern end of San Mateo County, California. The range is approximately four miles long and one to two miles wide, and runs from northwest to southeast. Elevation ranges from sea level at the eastern end on San Francisco Bay to 1314 feet at the highest peak. *Callophrys*

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*fotis bayensis* has been collected in at least six localities in the San Brunos. These localities are generally situated on north-facing slopes where moisture is conserved and the foodplant grows in abundance.

*C. f. bayensis* has been found in two localities outside of the San Bruno Mountains, both in San Mateo County. One locality is on a north-facing slope near the south end of Milagra Ridge, just north of Sharp Park Road at 400–550 feet elevation. This is about four airline miles southwest of the San Bruno Mountains. Immatures were taken here in April and May 1969, and in May 1970. Only about 50% of the adults from this population are typical *bayensis*; the remainder superficially resemble *C. f. schryveri* Cross, or *C. f. mossii* (H. Edwards).

The other locality, outside of the type locality, is on the northwest flank of Montara Mountain at 900–950 feet elevation, 1.1 air miles south of the Linda Mar School in Pacifica. This area, in the northernmost extension of the Santa Cruz Mountains, is about nine miles from the San Bruno Mountains. Immatures were collected here in April 1969, and adults were taken in March 1970. All specimens from this locality appear to represent typical *bayensis*.

Suitable habitats have not been found south of the Montara Mountain area. To the north of the San Bruno Mountains, two localities which have habitats similar to the type locality have been discovered. These localities, however, apparently do not support populations of *bayensis*, presumably because of limited foodplant biomass. One locality is on the north slope of Twin Peaks in San Francisco at 700–800 feet elevation where a fairly extensive *Sedum spathulifolium* colony grows. In the past, this area may have supported a *bayensis* colony which was exterminated through the gradual destruction of the habitat by housing developments.

The other locality is on a north-facing slope 1.0 air mile west of Yellow Bluff in the Fort Baker Military Reservation, south of Sausalito in Marin County. This area is about seven airline miles from the San Bruno Mountains. While the foodplant is locally abundant here, repeated visits have failed to produce evidence that *bayensis* occurs in the area. Further north in Marin County, a distinct new subspecies of *Callophrys fotis* has been found in a habitat markedly different from that which supports *bayensis*. This new subspecies is being described in a separate paper.

Fig. 1 shows the known distribution of *bayensis*; records of adult and larval collections are given below.

#### Habitat and Foodplant

An excellent description of the climate, geology, and flora of the San Bruno Mountains is provided by McClintock & Knight (1965). The



FIG. 1. Map showing locations where *C. fotis bayensis* occurs. The stippled circles represent the known colonies. SBM = San Bruno Mountains; SP = Sharp Park; M = Montara Mountain.

Milagra Ridge and Montara Mountain localities have a climate and habitat which are very similar to those of the localities in the San Bruno Mountains.

As noted above, *bayensis* is typically found on steep north-facing slopes where its foodplant, *Sedum spathulifolium* Hooker (Crassulaceae), grows abundantly. Representative vegetation on these slopes includes *Rhus diversiloba* Torr. and Gray (Poison Oak), *Berberis pinnata* Lag. (Coast Barberry), *Baccharis pilularis* DC. (Coyote Brush), *Anaphalis margaritacea* (L.) Gray (Pearly Everlasting), *Erigeron glaucus* Ker. (Seaside Daisy), *Dudleya farinosa* (Lindl.) Br. and R., *Arabis blepharophylla* H. and A. (Coast Rock Cress), *Eriogonum latifolium* Sm. (Coast Buckwheat), *Ranunculus californicus* Benth. (California Buttercup), and *Lomatium utriculatum* (Nutt.) C. and R. (Bladder Parsnip).

*Sedum spathulifolium* blooms from April to June. In areas where the

plant is abundant, the bright yellow flowers and red stems form a virtual carpet of color over the rocky ground. These colors are reflected in the cryptic patterns on the third and fourth instar larvae (see larval description below).

### Field Observations of Adults and Immatures

Emergence of adults takes place primarily during the month of March. A series of adults taken on 15 March 1970 exhibits a complete spectrum between worn and fresh specimens. In some years, a few adults probably emerge as early as late February.

No visits to the habitat of *bayensis* were made earlier than 1030 PST, at which time flight activity appeared to be maximal. It would appear that flight begins at least an hour earlier in the day. No data were obtained on flight activity during the afternoon hours. Adults of both sexes remained in close proximity to the foodplant. Males were much more active than females, often landing repeatedly on small shrubs, and they appeared to exhibit territorial behavior. Several males were noted nectaring at flowers of *Ranunculus californicus*, *Arabis blepharophylla*, and *Lomatium utriculatum*. Females tended to settle on the foodplant where they remained unless disturbed, and then they flew only short distances.

Oviposition takes place in March and early April. In one of the San Bruno Mountains localities, a total of five ova were located on leaf upper-sides of the foodplant. Confined females oviposited freely on both upper-sides and undersides of *Sedum* leaves.

The first and second instar larvae bore into the succulent leaves. By the time the third instar is reached in nature, the *Sedum* plants are beginning to bloom and the larvae generally move up to the flowerheads to feed. In many cases, the larvae fail to locate flowering stalks, and feed through to maturity on the centers of leaf rosettes. Brown (1969b) states that the color of the mature larva depends upon the color of the part of the foodplant on which it feeds; we noted no such relationship. Larvae reared by Ferris on leaves alone displayed three distinct color morphs. In the field, Emmel observed mature larvae of the various color morphs to be randomly distributed with regard to the color of the foodplant parts on which they were feeding. Myrmecophily was never observed in the field studies.

Pupation was not observed in the field, but probably occurs in ground litter under or near the *Sedum* plants. Eclosion of adults in the laboratory invariably occurred during the early morning hours, usually within an hour of being exposed to the first light of day.

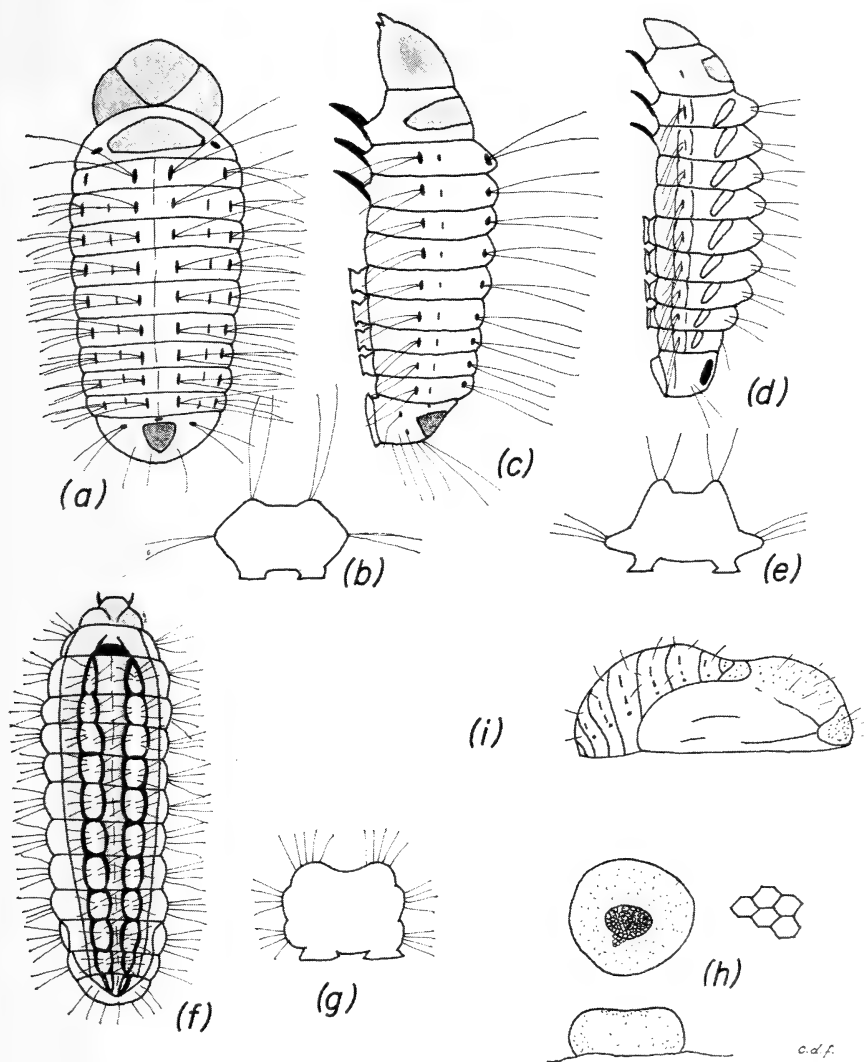


FIG. 2. Larva, ovum, and pupa of *Callophrys fotis bayensis*: a. first instar larva, dorsal view; b. first instar larva, cross-section through middle segment; c. first instar larva, lateral view; d. second instar larva, lateral view; e. second instar larva, cross-section through middle segment; f. third instar larva (mature), dorsal view in normal feeding position; g. third instar larva, cross-section through middle segment; h. ovum, dorsal and lateral views and enlargement of hexagonal cell pattern; i. pupa, lateral view.

### Description of Immature Stages

In March 1970, several females collected by Emmel in the San Bruno Mountains were confined over *Sedum spathulifolium* plants to obtain ova for life history studies. These females were placed in small jars containing several leaf rosettes of the foodplant. The jars were covered with netting and placed under a goose-neck lamp using a 75 watt bulb. The females oviposited freely on the *Sedum*. The ova obtained were sent to Ferris, who reared them on transplanted specimens of *Sedum spathulifolium* and described the immature stages.

**Ovum:** The eggs were pale green oblate spheroids approximately 0.8 mm in diameter. The eggs hatched in five to six days, and turned opaque white prior to emergence of the larvae.

**First instar:** The first instar larvae were pale yellow-green with clear hairs upon emergence from the eggs. They turned somewhat darker prior to moulting. The newly emerged larvae did not eat the egg shells. Stadium one lasted two days and the larvae increased in size from 1 mm to 2 mm.

**Second instar:** In this instar, the larvae were pink with pale hairs. Stadium two lasted three days with growth increase from 2 mm to 3 mm. The mature second stadium larvae varied in color from pale to dark pink.

**Third instar:** Initially, the larvae were a dark cream or straw color with considerable pink mottling, and were covered with short black spines. The larvae remained in the third instar from 9–12 days. Larval length reached 1 cm. In this stage, various color morphs developed. The mature stadium three larvae varied from yellow to cherry red, with greenish mottling. The caterpillars spent 24 to 48 hours in the transformation to the fourth instar. They remained motionless and contracted in length to about 7 to 8 mm before moulting.

**Fourth instar:** The fourth instar larvae exhibited three color morphs from the beginning. Some were yellow, some pale orange, and others cherry red, all with short dark bristles. There were pronounced chevron markings dorsally on the segments, at first in a similar, but darker color than the background. Later, the chevrons were dark cherry red. Some of the yellow larvae had very light or absent chevron markings. This instar lasted about 15 days with growth from 1 cm to 2 cm. A sample of 89 larvae collected in the San Bruno Mountains on 23 May 1971, showed the following numbers of the three principal color morphs: "red," 63 (71%); "yellow," 5 (6%); "light orange" or "intermediate," 21 (24%).

**Pupa:** The fourth stadium larvae spent three days in the prepupal stage. They were motionless during this period and contracted considerably in length. Initially the pupae were pale pink, but turned quickly to pale brown. They exhibited short hairs dorsally. The pupae measured from 0.7 to 0.9 cm in length. Pupation occurred on the earth in the debris at the bottom of the rearing jars.

The transformation from ovum to pupa required an average of 34 days under laboratory conditions of 20° C. and 12 hours of artificial sunlight per day.

The larvae were voracious feeders and were peripatetic. While feeding, they remained relatively motionless and burrowed into the leaves of the hostplant, leaving a large pile of frass behind them. This created some problem with rearing, as the excreta molded quickly, and tended to produce mold on the anal end of the larvae. The first instar larvae fed on the small leaves in the center of the *Sedum* rosette. They appeared in-



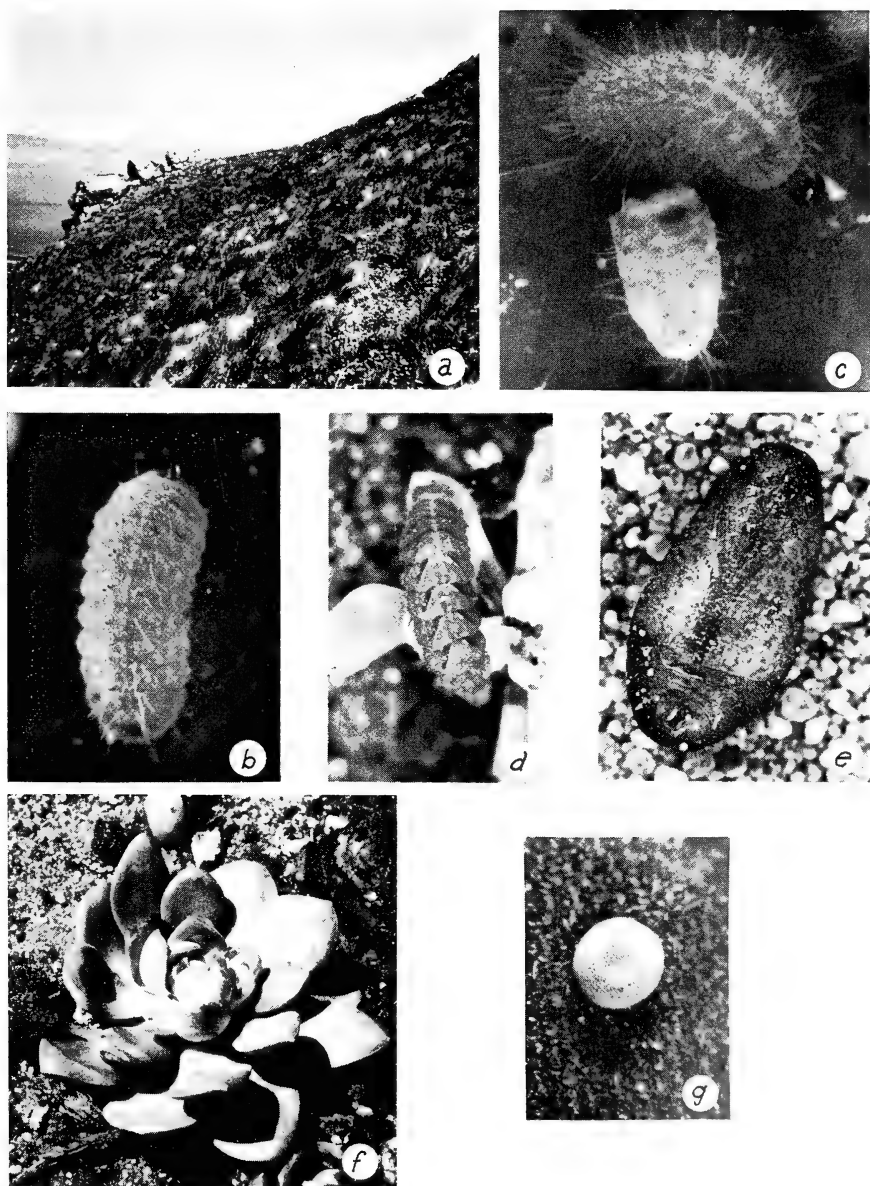


FIG. 3. *Callophrys fotis bayensis*: a. habitat in the San Bruno Mountains, San Mateo Co., California; b. second instar larva preparing to moult; c. new third instar larva, note cast-off skin and black head capsule; d. mature fourth stadium larva; e. pupa; f. young hostplant *Sedum spathulifolium*, the stage when oviposition occurs; g. ovum.

quisitive or pugnacious and reared up their heads whenever an object came near. The third and fourth instar larvae totally devoured the food-plant, both leaves and stems. Prior to each moult, the larvae spun a light silk mat to which they anchored themselves. The cast-off skins were not eaten.

### Distribution Records

CALIFORNIA. **San Mateo Co.:** slope 2 air miles W of Sierra Point, 1000', San Bruno Mts., 1 ♂, 1 ♀, 21-III-69; ravine 1.7 air miles WNW of Sierra Point, 700-800', San Bruno Mts., 5 ova on leaf uppersides of *Sedum spathulifolium*, 13-IV-69; at S end of Milagra Ridge, along and N of Sharp Park Road, 4 second-third instar larvae on flower buds and leaf rosettes of *S. spathulifolium*, 29-IV-69; same locality, 24 third-fourth instar larvae on flowers of *S. spathulifolium*, 14-V-69; same locality, 22 first-third instar larvae on flower buds and leaf rosettes of *S. spathulifolium*, 29-IV-70; on NW flank of Montara Mountain, 1.1 air miles due S of Linda Mar School, 925', 7 second-third instar larvae in centers of leaf rosettes of *S. spathulifolium*, 29-IV-69; same locality, 5 ♂, 1 ♀, 16-III-70; ravine 1.6 air miles WNW of Sierra Point, 800-1000', 15 third-fourth instar larvae on flowers of *S. spathulifolium*, 29-V-69; slope 1.2 air miles ESE of 1314' summit, on NE slope of San Bruno Mts., 850-1000', 24 ♂, 20 ♀, 15-III-70; same locality, ca. 40 third-fourth instar larvae on flowers and leaf rosettes of *S. spathulifolium*, 17-V-70; same locality, 27 ♂, 16 ♀, 28-III-71; same locality, 89 second-fourth instar larvae on flower buds and leaf rosettes of *S. spathulifolium*, 23-V-71; along crest of range 0.7 air mile SE of 1314' summit, San Bruno Mts., 1000-1100', 1 ♂, 28-III-71; same locality, 1 ♂, 2 ♀, 3-IV-71; same locality, 16 second-fourth instar larvae on flower buds and leaves of *S. spathulifolium*, 14-V-71; east-facing slope 0.6 air mile NNE of 1314' summit, 600-650', San Bruno Mts., 15 second-third instar larvae on flower buds and leaves of *S. spathulifolium*, 7-V-71; same locality, 29 third-fourth instar larvae on flowers of *S. spathulifolium*, 31-V-71.

All of the above specimens were collected by J. F. Emmel. The type locality cited by Brown (1969a) is a northwest-facing slope 0.2 air mile west and slightly south of the 1314' summit, 1000-1100', San Bruno Mts.

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THE TYPE LOCALITY FOR TWO MOTHS (PYRALIDIDAE,  
SATURNIIDAE) COLLECTED BY LT. W. L. CARPENTER,  
U.S.A., IN COLORADO, 1873

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In 1874 A. S. Packard described *Crambus carpenterellus* and *Hemileuca diana* from material collected by Carpenter while on the Hayden Survey in Colorado. Since Dr. A. B. Klots has need for a reasonably precise type locality for the crambid, I have investigated for him and find that one can be selected. The basic data are found in F. V. Hayden's "Annual Report . . . for the year 1873," published in 1874.

The solution to the problem for *Hemileuca diana* is easily found. Packard wrote (1874:557) of the source: "Plum Creek, September 12 (Lieutenant Carpenter)." There are a number of Plum Creeks in Colorado. The one involved (see Peale, p. 199) lies in Douglas County and drains the foothills from Palmer Lake northward almost to Littleton where it enters the South Platte River. In 1873, as today, two roads traveled along the principal branches of Plum Creek. The older road follows Plum Creek southward from the junction with the South Platte and gains the Platte-Arkansas Divide via the west branch. The railroads and the main highway, Interstate 25, follow the east branch to Larkspur and then strike due south, or continue to Palmer Lake.

The easternmost tributary of East Plum Creek heads at Palmer Lake and is the stream farthest south in the system. This stream was named Carpenter Creek by the Hayden Survey. A good type locality for *Hemileuca diana* would be headwaters of East Plum Creek between Larkspur and Palmer Lake. The extent of Plum Creek is found on the U.S.G.S. 7½ min. quadrangles Dawson Butte, Kassler, Larkspur, Littleton and Sedalia.

Packard's statement about the source of his series of *carpenterellus* is vague. He wrote (p. 548) "Mountains of Colorado, July 19, August 12, September 8 (Lieutenant Carpenter)." The September date is the earliest one mentioned in the report for return to the eastern foothills of the mountains after a summer near and about the continental divide. The published evidence (p. 556) is that Carpenter was still on the "Pacific slope" as late as 6 September. Other evidence in the report places the party at the head of Eagle River on the north slope of Tennessee Pass at this time. The shortest possible horseback route from the camps on the

upper Eagle River to the foothills around Turkey Creek is 120 miles. Even a hardened cavalryman of the 1870's would find that ride a noteworthy one to accomplish and collect specimens on both 6 and 8 September. There are three references (p. 548, 549 and 556) to material collected in the foothills on 8 September by Carpenter. Perhaps the 6 September date is wrongly placed on the Eagle River.

The date 12 August is referred to several times. On p. 551, 553 and 554 it is associated with "in the mountains." On p. 567 Osten-Sacken wrote of willow galls collected by Carpenter: "those taken on East River, August 12, still contained the caterpillars. . . ." East River is a tributary of the Gunnison River in western Colorado. It has its headwaters in a lake on the south side of Schofield Pass above Gothic in Gunnison County. The river flows southward and joins the Gunnison at Almont. Willows (*Salix*) are common along the banks of the East River throughout its course. Since the Survey spent considerable time mapping the Elk Mountains, and Schofield Pass is in those mountains, I suspect that Carpenter collected somewhere near Gothic on the East River, rather than in the *Atriplex*-grasslands nearer the Gunnison River. The entire East River lies in Gunnison County and is shown on U.S.G.S. 7½ min. quadrangles Almont, Cement, Crested Butte, Gothic, Oh-be-joyful and Snowmass Mountain.

"In the mountains" is associated with the date 19 July on a number of pages—548, 549, 551, 556, etc. The nearest dates associated with definite localities are 16 July at Fairplay (p. 548) and 21 July at Twin Lakes (p. 562). In 1873 there were three routes by which Carpenter might have traveled from Fairplay to Twin Lakes. Gannett (p. 675) described each of them as follows:

"In the Park Range the most northerly pass is Mosquito Pass at the head of Mosquito Gulch. Its elevation is 13,438. The ascent is steep, and difficult for pack animals on both sides; except in mid-summer, there is a great deal of snow on the trail."

"Weston's Pass, Park Range, at the head of the Little Platte. Elevation 11,676. A good wagon-road crosses this pass. The ascent on the South Park side is by easy grades, but on the Arkansas side it is much steeper."

"Trout Creek Pass, Park Range. Elevation 9,346 feet. This pass is through the low rugged hills south of Buffalo Peaks, and near the salt works. The stage-road to Arkansas Valley crosses this pass. It is an extremely easy one."

Today, 100 years later, the last is the only one of the three passes in regular use, being the pass by which U.S. Highway 24 crosses the "Park Range," now called the Mosquito Range.

Hayden himself gives us the clue to which pass was used. On p. 49 he wrote of the work in the Park Range "our last move was along the divide from Weston's Pass to the base of Buffalo Peaks." This move was made

on 22 July. Apparently while Hayden and the surveyors went to occupy their station on Buffalo Peaks, Carpenter and an advance party moved to Twin Lakes. Thus we can be quite sure that the 19 July specimen(s) of *Crambus carpenterellus* were collected in the vicinity of Weston Pass on the boundary between Park and Lake counties. Good camp could easily be made on the Park County side of the pass. In fact, I camped there myself in the 1930's. It is an area of typical Hudsonian forest, grassland and bog. The region is well shown on U.S.G.S. 7½ min. quadrangles Mount Sherman and South Peak.

Faced with selecting one of these three diverse localities as the type locality for *carpenterellus*, I reneged and passed the problem to Dr. Klots. He wrote to me "July 19 is the most logical of the three dates . . . for this species to be flying. August 12 is possible, but it would be pretty well gone by then. I think September 8 would be much too late." Thus Dr. Klots settled upon Weston Pass, Park County, Colorado to be the type locality for *Crambus carpenterellus* Packard.

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#### THE MATURE LARVA OF *SPHINX VASHTI* (SPHINGIDAE)

*Sphinx vashti* Strecker is widely distributed in the western half of North America (Hodges 1971, in Dominick et al., The Moths of America North of Mexico, Fascicle 21, Sphingoidea: p. 59-61). The egg, larva, and pupa were first described by Dyar (1894, Psyche 7:177), who reared it on Snowberry (*Symphoricarpos albus*). Recently, Comstock (1966, J. Res. Lepid. 5:218-219) described and figured the egg and first instar larva. The mature larva is depicted here for the first time.

On 14 July 1958 I found a larva feeding on Coralberry (*Symphoricarpos orbiculatus*) in the front yard of my home in Ottawa, Kansas. The mature larva is pale apple green with blue-green granulations on the dorsum. The lateral oblique lines on the abdomen are lavender or purplish-red. The caudal horn is dark red to deep blue at the tip. In Dyar's specimen the lateral lines were



Fig. 1. Mature larva of *Sphinx vashti*.

white, edged anteriorly with a narrow black line, and the caudal horn was greenish white; black above, below, and at the tip.

The larva pupated in the soil on 22 July 1958, spent two winters as a pupa (the soil was never moistened), and produced an adult female on 6 May 1960.

This species, single-brooded and always rare in Kansas, has occasionally been taken visiting honeysuckle blossoms in late May and June. I have taken several adults visiting columbines (*Aquilegia*) in the early evening in Gunnison National Forest, Ohio City, Colorado in mid-July. Fleming (1970, Mich. Entomol. 3:17-23) did not include any feeding records for the adults of *Sphinx vashti*, but his review was primarily of eastern species.

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A PROPOSAL FOR THE UNIFORM TREATMENT OF  
INFRASUBSPECIFIC VARIATION BY LEPIDOPTERISTSJOHN H. MASTERS<sup>1</sup>

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The binomial system of zoological nomenclature dates back to Linnaeus' 10th edition of *Systema Naturae* in 1758. The trinomial was not conceived by Linnaeus, however, and did not come into extensive use until the last half of the 19th century. While Linnaeus created the binomial system, he did not propose any sort of rules for the naming of animals. A great deal of confusion resulted and in the early 19th century a number of codes were proposed, mostly imposing a basic philosophy for priority of names, in attempts at solution. At the First International Congress of Zoology, held in Paris in 1889, Raphael Blanchard submitted a proposed set of international rules for naming animals. Blanchard's rules were formally adopted at the Second Congress in Moscow in 1892 and have been subsequently revised until the present *International Code of Zoological Nomenclature* was adopted by the Fifteenth Congress in London in 1958 and was officially published in 1961.

Under the present Code (1961) the trinomial is restricted in usage to geographical subspecies and all other types of infraspecific variation are considered as infrasubspecific and are removed and excluded from the provisions of the Code. This decision, by the International Commission, was not meant to imply that the study of infraspecific categories other than the subspecies is unimportant, but to emphasize the fact that subspecific variation is essentially different from any of the others. Subspecific variation is generally considered to be the first stage of the speciation process and those populations which are currently treated as subspecies are so treated subjectively and may be, in any later revision, elevated to the species level. Because the subspecies names is subject to elevation to the species level (and conversely, species names are subject to reduction to the subspecies level), it is essential to retain it in the species-group where it is liable to those rules and criteria, including priority, which apply to the species name.

The geneticist, and many others, may regard other types of infraspecific variation as more important than subspecies; however infrasubspecific variants are not subject to elevation to the species category and there was deemed to be no need to conserve priorities or other protection under the provisions of the Code.

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## INFRASUBSPECIFIC VARIATION

Other than a general agreement that infrasubspecific names should not be placed in italics, as are the species-group names, lepidopterists have not given them anything approaching a standard treatment in the last decade. There has been, however, a very sharp decrease in the publication of formal names to apply to infrasubspecific variation during the last twenty years. While a few names still appear, most authors are content to describe examples of infrasubspecific variation without attempting to formally name them.

Designations for many types of infrasubspecific variation seem at least useful, if not necessary, and if they are to be designated, it is highly desirable that a consistent and uniform method be used for citing them. It is not necessary that priorities or rules of Latin word formation be followed, nor is it essential that usage in Lepidoptera be consistent with that in other orders of insects or in other classes of animals. The opportunity is clearly present for lepidopterists to develop a system of designation suitable for present day needs without concern for the stigmas of priorities and validities that have made this impossible in the past. With the vacillation of the I.C.Z.N. in the area of infrasubspecific designation, it is unlikely that mandatory rules will ever be adopted. Consistent usage can only come through common acceptance of the majority of lepidopterists. It is my hope that this proposal for a rational, uniform treatment of infrasubspecific categories will eventually lead to a standard and uniform treatment by lepidopterists around the world.

Infrasubspecific designations in Lepidoptera have been employed for an assortment of variations, all of which involve maculation (phenotype expression), some, but not all, of which involve genotype and none of which, at least directly, involve physiotype. For practical purposes, they all can be grouped into four distinct categories: (1) polychromatic or polymorphic forms, (2) mutant or aberrational forms, (3) seasonal or brood forms, and (4) hybrids. Each of these presents an entirely different set of circumstances and the criteria for designation must be dealt with individually.

## Polychromatic or Polymorphic Forms

Ford (1940) defined the condition of polymorphism as "the occurrence together in the same habitat of two or more discontinuous forms, or phases, of a species in such proportions that the rarest of them cannot be maintained merely by recurrent mutation." Polymorphic forms are perhaps best known to North American lepidopterists in the yellow or white color phases of female *Colias* species. They are most pronounced



in the various mimetic female forms of certain African and Indo-Australian *Papilio* species, e.g. *Papilio dardanus* Brown or *Papilio polytes* Linnaeus. These are clearly genetic situations and, in fact, the genetics of many of them have been carefully studied and worked out by breeding in the laboratory. The discontinuous factor is important for considerations of polymorphism, for continuous variation that could be plotted on a curve of normal distribution, such as the length of forewings, is excluded. (For detailed discourse on the genetic aspects of polymorphism, see Ford (1965).)

Nearly all of the North American *Colias* species exhibit dimorphic yellow vs. white female color phases (for detailed information, see Hovanitz, 1950), and many names have been proposed to refer to the white form: "alba" Strecker, "albida" Chermock, "canescens" Comstock, "flavocincta" Cockerell, "hatui" Barnes & Benjamin, "neri" Barnes & Benjamin, "medi" Gunder, "lambillioni" Dufrane, "martini" Gunder, "pallida" Cockerell, "pallida" Skinner, "pallidice" Scudder, "pallidissima" Bowman, and "shastae" Barnes & Benjamin. While roughly 50% of these names are more or less descriptive of the color condition, the genetic factors creating the white or yellow phases are identical, or nearly so, for all of the species in the genus and there is no reason why a single descriptive name should not be employed as a *nomen collectivum* to apply to the equivalent forms in each species. However, since both white and yellow forms are normal genetic components of the population, it would not be proper to apply a designation to the white form without an equivalent designation for the yellow form. It is my proposal that the name "alba" be employed as a descriptive and collective name for the white color phase in *Colias* species, and that "flava" be similarly employed to designate the yellow phase. If desired, "chrysa" could be added to distinguish those populations with an orange phase from those with a yellow phase.

The use of a collective-descriptive designation, as cited in the example of *Colias*, seems to be the most practical way to deal with polymorphic variation. To avoid confusion with species-group names, these names should be enclosed in quotation marks but not italicized. Since they are not subject to the laws of priority and since they are descriptive, there is no need to append an author's name. (Author's names are appended to species-group names to facilitate the reference to an original description, not to honor the author.) The use of Latin to derive the collective-descriptive names seems preferable to a contemporary language because it will have equal meaning in international usage and will discourage translation into vernacular vocabulary. There is, of course,

some loss of descriptive value in the Latin derived names, as most biologists in the present day are not Latin scholars. With slight modification, collective-descriptive designations can be adapted to polymorphic as well as polychromatic situations.

Additional examples of polychromatic situations are: *Heliconius doris* (Linnaeus) which is sympatrically trichromatic in both sexes with red, green and blue color phases which could be referred to, respectively, as "erythro," "chloro" and "cyano." Similarly, the dimorphic female color phases of *Papilio glaucus* Linnaeus could be treated as "flava" for the yellow examples and "atrata" for the dark ones. The blue and brown color phases of certain female Lycaenidae, e.g. *Plebejus saepiolus* (Boisduval), could be collectively indicated as "cyana" and "atrata." Similarly, "cyana," "atrata" and "bicolor" could be used in reference to the brown, blue and mixed females of *Morpho aega* Hübner. The silvered and unsilvered varieties of *Speyeria* and related genera might be referred to as "argentamaculosus" and "flavomaculosus" respectively.

For non-chromatic polymorphic forms, the system is not as simple for there may be no simple descriptive term that could be used to designate the various forms. In many of these cases, the various polymorphic forms are apparent mimics of other species and it is appealing to compose a compound name of the prefix "pseudo-" along with the specific name of the model species.<sup>2</sup> As an example of non-chromatic polymorphism consider the various polymorphic females of *Papilio dardanus cenea* Stoll in South Africa. Van Son (1949) lists eleven distinct named forms of the female of *Papilio dardanus cenea* all of which show a remarkable phenotype expression and all of which are strikingly distinct from the male phenotype. All of these forms are apparent mimics of distasteful or protected species of Danaidae or Craeidae, which allows us to coin a collective-descriptive name based on the model-mimic relationship. *Papilio d. cenea* form "hippocoonides" Haase, which mimics *Amauris niavius dominicanus* Trimen, would be designated as *Papilio d. cenea* "pseudodominicanus" which is both simpler and more meaningful; similarly, form "trophonius" Westwood, which is a mimic of *Danaus chrysippus* Linnaeus, would become "pseudochrysippus"; and the other forms could be similarly named for the species they mimic.

For situations where males and females are dimorphic with respect to each other but constant within the same sex, e.g. *Neophasia terlootii* Behr, with white males and brick orange females, no infrasubspecific designation is required or desirable. For species which display a great

<sup>2</sup>The Code (recommendation D13) advises against the use of the prefix pseudo- with non-noun or adjectives; however this is the simplest procedure to use in collective-descriptive nomenclature and infrasubspecific usages are clearly not governed by the Code in any case.

deal of random variation, e.g. *Parnassius phoebis* Fabricius, collective-descriptive names could be utilized to refer to the various individual variants. Eisner (1955) (see also Brown, 1956) proposed a total of 66 collective-descriptive names for application to variation that he had observed in the genus *Parnassius*. Many of the variants referred to by Eisner represent aberrations rather than polymorphisms and are treated in the following section. Unless a variant is fairly regular in occurrence and there is good reason to suspect a genetic cause for it, I see no reason or need for an infrasubspecific designation.

In using collective-descriptive names for polymorphic forms, setting the names in another typeface (e.g. **boldface**), but not italics, could be considered as an alternative to enclosing them in quotation marks. Intervening qualifying phrases (e.g. form as in *Colias gigantea* ♀ form "alba") would be optional usage.

### Mutant or Aberrational Forms

Aberrations, mutants or "sports" are encountered with fair frequency among Lepidoptera. Many of these forms (mutants) have genetic cause but, unlike polymorphic forms, they are extremely rare in occurrence and not a normal part of the population. If the same sort of mutant reappears from time to time, it is assumed to be maintained by recurrent mutation rather than by selection. Other aberrational forms are produced by environmental causes. For example, it is well known that aberrant specimens of *Euphydryas phaeton* (Drury) can be artificially produced by exposing pupae to near freezing temperatures at a critical time in their development. As a general rule, these forms are much rarer in occurrence than are polymorphic forms; in the majority of cases their actual percentage of occurrence in a population would be less than 0.01% (one in 10,000). A polymorphic form may be this rare in a local population, but not throughout its entire range and, in some cases, an environmentally induced aberrant may be considerably more common than this during a single brood, but not on a continuing basis.

In the not too distant past, there was a strong tendency to adorn each mutant or aberrational form with a formal name. At present, they are rarely named, but are frequently described and reported in the literature. Whether genetic or non-genetic in cause, aberrants normally are not an integral part of any population; each specimen is an individual without direct continuity with any succeeding individuals which may resemble it. Putting a name, formally or informally, on aberrant specimens serves no useful purpose, and might serve to confuse them with polymorphic forms. It should be kept in mind, however, that mutant forms are the

raw material for evolution and that they may become established as polymorphic forms through selection.

Sexual mosaics and gynandromorphs are considered by me to fall into this category of aberrational forms.

### Seasonal Forms

Seasonal forms are most pronounced in the areas of Africa where there is a considerable seasonal variation in rainfall. The "wet" and "dry" season forms of some species, particularly of the genus *Precis* (Nymphalidae), are so completely distinct in appearance that they were described as distinct species. In North America, seasonal forms are best known in the distinct brood forms of *Eurytides marcellus* (Cramer) (Papilionidae), *Celastrina argiolus* (Linnaeus) (Lycaenidae), various *Pieris* species (Pieridae) and various *Polygonia* species (Nymphalidae).

Seasonal forms may be considered environmental in nature, as the changes in appearance are brought about in response to environmental conditions, in most cases differences in solar radiation or differences in humidity, and not by genetic change. Of course genetic factors control the seasonal changes, since some species have seasonal forms while closely related ones may not. In some cases, changes in active genes may be responsible for the phenetic differences, but both forms are identical in terms of total genome, one form flowing from the other via direct inheritance.

A great deal of nomenclature has been expended, in the past, in treatment of seasonal variation where the variation involved is clearly the result of common factors. For instance, *Pieris sisymbrii* Boisduval, *Pieris protodice* Boisduval & LeConte, *Pieris occidentalis* Reakirt, *Pieris napi* (Linnaeus) and *Pieris rapae* (Linnaeus) have, in common, a situation in which the early spring brood is heavily marked on the ventral hind-wing while summer or fall broods are relatively immaculate. Many names have been formally proposed to cover this situation in *Pieris* (including "transversa" Barnes & Benjamin, "vernalis" Edwards, and "nasturtii" Edwards for the spring forms; and "acadica" Edwards, "cruciferarum" Boisduval, "aestiva" Harris, "castoria" Reakirt, "iberidis" Boisduval, "pallida" Scudder, "pallidissima" Barnes & Benjamin, and "yreka" Reakirt for the summer forms). All of these could readily be eliminated by using "vernalis" as a descriptive-collective name for all of the spring broods and by using "aestivalis" as an equal descriptive-collective name for the summer broods. This same system could be used in the case of all species having seasonal or brood forms; the descriptive

names "autumnalis" and "hyemalis" could be added to cover fall or winter forms as required.

However, I feel that a preferable treatment for seasonal or brood forms would be to assign the successive generations a Greek letter designation. Thus the spring broods of the *Pieris* species cited above, could be given the designation  $\alpha$  (alpha), and the summer broods could be designated by  $\beta$  (beta).

Compare the following methods of designating the two distinct spring and summer broods of *Eurytides marcellus*.

Method I, using commemorative names with priorities:

<i>Eurytides marcellus</i> (Cramer) form "walshii" (Edwards)	
	[early spring brood]
<i>Eurytides marcellus</i> (Cramer) form "telamonides" (Felder & Felder)	
<i>Eurytides marcellus</i> (Cramer) form "lecontei" (Rothschild & Jordan)	
	[summer brood]

Method II, using collective-descriptive names:

<i>Eurytides marcellus</i> (Cramer) "monovernalis"	[early spring brood]
<i>Eurytides marcellus</i> (Cramer) "bivernalis"	[spring brood]
<i>Eurytides marcellus</i> (Cramer) "aestivalis"	[summer brood]

Method III, using Greek-letter designations:

<i>Eurytides marcellus</i> (Cramer) $\alpha$ brood	[early spring brood]
<i>Eurytides marcellus</i> (Cramer) $\beta$ brood	[spring brood]
<i>Eurytides marcellus</i> (Cramer) $\gamma$ brood	[summer brood]

It is my feeling that method III is preferable, as there would be no ambiguity such as might result if collective-descriptive names, albeit different ones, were used for both polymorphic and seasonal form designations.

### Hybrids

In Lepidoptera, hybrids are not excessively rare in nature and, in some cases, can be produced with a degree of efficiency in the laboratory. We must, however, recognize four distinct classifications of hybrids: (1) hybrids between two subspecies of the same species, (2) hybrids between two distinct species of the same genus, (3) hybrids between two species of different genera, and (4) hybrid populations that are viable and breeding, although resulting from the hybridization of two distinct species.

Where both parents are known, a hybrid can be readily designated by joining the two species-group names with a multiplication sign ( $\times$ ).

(1) For hybrids between subspecies of the same species, such as between *Limenitis arthemis arthemis* (Drury) and *Limenitis arthemis astyanax* (Fabricius), the designation would be *Limenitis arthemis* (*artemis*  $\times$  *astyanax*) or *Limenitis arthemis* (*astyanax*  $\times$  *artemis*). The name of the male parent, if known, should precede that of the female parent.

(2) For hybrids between two species of the same genus, such as *Limenitis arthemis* and *Limenitis archippus* (Cramer), the combination would be *Limenitis arthemis*  $\times$  *archippus* or *Limenitis archippus*  $\times$  *artemis*.

(3) For the much rarer situation of hybrids between two species of distinct genera, e.g. hybrids between *Phyciodes tharos* (Drury) and *Chlosyne nycteis* (Doubleday), the designation would be simply *Phyciodes tharos*  $\times$  *Chlosyne nycteis*, or *Chlosyne nycteis*  $\times$  *Phyciodes tharos*.

(4) In Lepidoptera there are, albeit very rarely, viable, breeding populations resulting from hybridization between two closely related species. *Papilio kahli* Chermock & Chermock is one of the better known examples of these, and has been treated in detail by Remington (1958), who concluded:

"1) Riding Mountain is the locus of origin of *P. kahli*, an isolated, distinctive offshoot of *P. polyxenes* with black wings, spotted abdomen, and large acentric 'pupil.' 2) In relatively recent times *P. machaon* arrived on the plateau, perhaps carried from Alberta in hay or straw during the development of the National Park or of highways or railroads. 3) These two *Papilio* at first lacking behavioral and other isolating mechanisms, hybridized rather freely; the distinctive genotype of *P. kahli* allows the  $F_1$  heterozygotes to show some yellow-wing characters never seen in laboratory crosses of *machaon* with true *polyxenes*. 4) Since *P. kahli* and *P. avinoffi* belong to separate species, one expects that isolating mechanisms are evolving in Riding Mountain populations and that eventually natural hybrids will no longer be produced. Meanwhile, each species may be incorporating into its genotype new adaptive alleles from the other species (introgression). There is little basis for regarding *kahli* as dimorphic in the sense of *P. glaucus* females. For the present, these Riding Mountain swallowtails may be called *P. kahli* (or *P. polyxenes kahli*), *P. machaon avinoffi* and their hybrids."

*Papilio nitra* Edwards is another North American *Papilio* that represents a situation similar to that of *Papilio kahli*. Warren (1969) cited four populations of Old World *Pieris* (*dubiosa* Rober, *balcarica* W. & N., *pseudorapae* Vty. and *meridionalis* Heyne) which he considered hybrid races.

Hybrid races such as these may be referred to by specific names of the species group type—subject to priorities and other provisions of the

Code—as though they were true species; however the generic name should be preceded by the sign of multiplication, e.g.  $\times$  *Papilio kahli*, or  $\times$  *Pieris balcarica*.

## HOW TO DETERMINE WHETHER A NAME IS SUBSPECIFIC OR INFRASUBSPECIFIC

It is necessary to recognize subspecific names and infrasubspecific names and to distinguish between them. The provisions of the Code (my treatment here is adapted from Field, 1971) are summarized here.

### Subspecific Names

Article 45 (d) of the Code dictates three situations under which we are to accept a proposed name as a subspecific name.

1. The original status of any name of a taxon of lower rank than species is determined as subspecific if the author, when originally establishing the name, clearly stated it to apply to a subspecies. Obviously the best way to propose a subspecific name is to state that it is a subspecies.

2. The original status of any name of a taxon of lower rank than a species is determined as subspecific if the author, when originally establishing the name, did not state its rank. This clearly means that if an author proposed a trinomial name without explaining the trinomen in any way, we are to accept it as a proposal of a subspecies.

3. The original status of any name of a taxon of lower rank than a species is determined as subspecific if the author, when originally establishing the name, stated the taxon to be characteristic of a particular geographical area (or geological horizon) and did not expressly refer it to any infrasubspecific category. This clearly covers all names proposed in the past as races, local forms, altitude forms, and the like, provided they were proposed as trinomial names.

### Infrasubspecific Names

Article 45 (d) (iii) gives two ways of recognizing when a taxon is of infrasubspecific status.

1. The original status of any name of a taxon of lower rank than species is determined as infrasubspecific if the author, when originally establishing the name, expressly referred the taxon to an infrasubspecific rank. This necessarily includes names given to all categories lower in rank than the subspecies and includes all names given to individual specimens and segments of populations such as aberrations, transition forms, seasonal forms, wet and dry forms, cold forms, color forms, sexual forms, and the names given to the separate generations of the same population.

2. The original status of any name of a taxon of lower rank than species is determined as infrasubspecific if the author, when originally establishing the name, after 1960, did not clearly state that it was a subspecies.

### “Varieties” and “Forms”

Paragraph (e) of article 45, interprets the usage of the terms “variety” and “form” as follows: (i) before 1961, the use of either of the terms ‘variety’ or ‘form’ is not to be interpreted as an express statement of either subspecific or infrasubspecific rank; (ii) after 1960, a new name published as that of a ‘variety’ or ‘form’ is to be regarded as of infrasubspecific rank. (This is also stated in article 15.)

For publications dated before 1961, we must study the author’s text to determine what he meant by his use of the terms “variety” and “form.” If the author clearly

indicates in his text that he is writing about an individual variant (such as an aberration, color form, or the like) that is part of a population, then we have to reject the name. On the other hand, if the original author in no way shows what he meant by the term "variety" or "form," or if it is not clear that he is naming either subspecies or individual variants of such population, or if his text clearly indicates that he is describing geographical variation of the modern subspecies concept, then we have to accept any such proposed trinomial name as an acceptable trinomial under article 45 (d) (i).

#### Acceptable Subspecific Names

In summary, there are five types of trinomial names that should be acceptable as subspecific names under the Code.

1. Names given as trinomials (article 5), as subspecies (article 45 (d) (i)).
2. Names given as trinomials (article 5), before 1961, where no expressed category or rank is indicated (article 45 (d) (i)).
3. Names given as trinomials (article 5), before 1961, as races, local forms, altitude forms, or given as trinomials, to any other geographically based population (article 45 (d) (ii)).
4. Names given as trinomials (article 5), before 1961, as "varieties" and "forms" where the author indicates or even hints that they represent geographically based populations (article 45 (d) (ii) and (e) (i)).
5. Names given as trinomials (article 5), before 1961, as "varieties" and "forms" where the author in no way indicates what he meant by the use of these terms (article 45 (d) (i) and (e) (i)). Many authors used these terms for subspecies. Article 45 (e) (i) allows us to accept these terms as subspecific unless it is apparent that an infrasubspecific category is intended.

#### Names Unacceptable under the Code

There are seven types of names that are excluded as subspecific names by the Code.

1. All names proposed as quadrinomials (article 5 by recognizing only the generic name, the specific name, and, when applicable, the subspecific name).
2. All names given to aberrations as such, transitional forms as such, seasonal forms, wet and dry forms, color forms, sexual forms, generation forms as such, and similar forms (article 1; article 45 (d) (iii) and glossary of the Code: definition of the term infrasubspecific).
3. All names given to "varieties" and "forms" before 1961, where the author clearly indicates that he is dealing with an individual variant such as one of those mentioned above under number 2 (article 45 (e) (i)).
4. All names proposed as trinomials after 1960, where it is not clearly stated that such names are subspecific names (article 45 (d) (iii)).
5. All names proposed for "varieties" or "forms" after 1960 (article 15, article 45 (e) (ii)).
6. All names proposed for races, local forms, altitudinal forms, or any geographically based populations, after 1960, where they are not expressly called subspecies (article 45 (a) and article 45 (d) (iii)).
7. All names given to hybrids (article 1).

#### Excluded Names Becoming Available

Names rejected or excluded under the Code may later become available, for article 10 (b) states that "a name first established with infrasubspecific rank becomes available if the taxon in question is elevated to a rank of the species-group, and takes the date and authorship of its elevation."



## SUMMARY

1. Taxonomic categories of lower rank than subspecies (infrasubspecies) have been removed from the protection of the "Code" (International Code of Zoological Nomenclature, 1961). This means that names proposed for infrasubspecific variation (including those proposed for polymorphic forms, aberrations, seasonal forms, sexual forms, color forms, altitudinal forms, etc.) do not have the regulation and protection of the Code under the laws of priority and uniform usage.

2. If names are to be used to designate infrasubspecific variation, they should be used in such a way as to avoid confusion with the subspecies or trinomial usage.

a. Names should be placed in quotation marks or some other typeface (such as **boldface**) and not in italics as are used for the species-group names.

b. These names should not take an author's name.

3. Since infrasubspecific names are not subject to the laws of priority or other provisions of the Code, the opportunity is clearly present for lepidopterists to develop a uniform system of designation suitable for present day needs without concern for the stigmas of priorities and validities that, ostensibly, have made this impossible in the past.

4. The following proposals are advanced to cover four major categories of infrasubspecific variation.

a. POLYCHROMATIC OR POLYMORPHIC FORMS should be described by collective-descriptive names. The use of Latin to derive the collective-descriptive names is preferred because it will have equal meaning in international usage and will discourage translation into vernacular vocabulary. The name "alba" as used to describe the white color phase of female *Colias* butterflies is an example of a descriptive name. Since a similar white color phase occurs by a similar genetic mechanism in nearly all species of *Colias*, the same name should be applied to similar color phases in all of them—thus it is a collective name.

b. MUTANT OR ABERRATIONAL FORMS are not an integral part of the population; each specimen is an individual and does not have any direct continuity with any succeeding specimen which may resemble it. Placing a name, formally or informally, on aberrant specimens serves no useful purpose and is to be discouraged entirely.

c. SEASONAL FORMS are environmental and not genetic in nature because the differing broods involved are genetically identical. Collective-descriptive names, such as are suggested for use with polymorphic variation, could be applied in this case; however, since polymorphic variation is quite distinct from seasonal variation and since a given

specimen may exhibit both polymorphic and seasonal variation, it is recommended that Greek-letter designations be employed to indicate seasonal variation. Starting with the first spring or first wet season generation, broods could be designated, successively, as  $\alpha$  (alpha),  $\beta$  (beta),  $\gamma$  (gamma), etc. broods.

d. HYBRID INDIVIDUALS can be indicated by joining the two species-group names with a multiplication sign. In those rare situations where an actual breeding population of hybrid origin exists, a species group name may be applied, but only if the entire name is preceded by a multiplication sign.

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*LIMENITIS LORQUINI* (NYMPHALIDAE) ATTACKING A  
GLAUCOUS-WINGED GULL

Readers of the encounter between a Monarch and a Red-winged Blackbird reported by Slansky (1971, J. Lepid. Soc. 25:294) may be interested in a similar pugnacious interlude. This occurred on the warm and sunny morning of 4 July 1970, in Beacon Hill Park, Victoria, British Columbia. On that day, along with lepidopterists JoAnne Pyle, H. Whetstone Pyle and Chuck Dudley, I was photographing butterflies for a work on the fauna of Washington. We were drawn into an ornamental rose garden by a superb, fresh *Limenitis lorquini burrisonii* Maynard. The Admiral, a male, was sunning on the roses and soaring slowly around the garden. There were no nectar sources, no female *lorquini*, nor any other attractants in view.

The butterfly was exceptionally approachable, more so than any others of its species I had encountered before. Photographing it presented little difficulty. Indeed, the "friendly" creature crawled onto my fingers and landed upon many bemused visitors to the garden. Despite considerable human activity in the area, the *lorquini* maintained this "tame" behavior. Then a sound, which had been constantly in the background, came nearer. A shadow passed over the garden as a Glaucous-winged Gull appeared from behind the crowns of a Douglas Fir wood. Suddenly, as the gull came directly overhead at a height of 20 to 30 feet, the Admiral darted up from his rose-blossom perch and accosted the gull. Again and again *lorquini* darted at the huge bird, never descending until the gull quit the area.

This remarkable spectacle occurred several times in a half-hour period. On each occasion, the pale seabird entered the arena of action and began to circle, only to be immediately enjoined by the Lorquin's Admiral. The height of engagement was consistently the same as Slansky reported for the Monarch and the blackbird—from 20 to 30 feet. Unlike the Red-winged Blackbird, however, this gull did not seem to react to what I interpreted as the butterfly's aggression. It called raucously, but no more than before or after the encounter; and it seemed to depart volitionally and not under stress. The gull made no attempt to deter or eat the Admiral.

Why was the *lorquini* indifferent to other movement through the garden, yet so demonstrative toward the seagull? One may speculate that the bird was recognized as a potential foe, rival male, or mate, and that the appropriate behavioral response was elicited. Attacking a potential predator would not seem very adaptive for a butterfly, and where I have seen male *lorquini* together before, they have passively coexisted. Therefore, the possibility of a courtship chase would seem most likely. Butterfly males have been known to pursue experimental super-female models: perhaps the same sort of perception and reaction was seen here.

It would be pleasing to see more ethological notes in this journal. I feel that, in regarding butterflies strictly as specimens for acquisition or research, we often ignore events which render these organisms fascinating in a living context: events such as this encounter between an Admiral and a seagull, which was just slightly less intriguing than a well known episode involving another kind of seabird, an albatross, and an aged seafarer.

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## BOOK REVIEWS

MICROLEPIDOPTERA PALEARCTICA; VOLUME 2. ETHMIIDAE, by Klaus Sattler. George Fromme & Co., Vienna. In two vols., text xvi + 185 p.; plates, 9 color 97 black & white, each with unnumbered expl. page facing. Dec., 1967. Subscription price: 1,160 Austrian schilling; full price: 1,365 Austrian schilling (about \$58.00). [text in German].

This, the second contribution of the ambitious project which plans to systematically treat and illustrate in color all microlepidoptera of the Palearctic Region, follows the same format set forth in Volume 1, the Crambidae, by the late Stanislaw Blezynski, in 1965. Principles of the project are explained in the forward to Volume 1 (see J. Lepid. Soc., 19: 117-125, 1965).

The treatment of the Gelechioid family Ethmiidae is taxonomically and mechanically accurate and concise throughout. It includes introductory parts dealing with historical development and associated problems in handling material and literature, technical aspects of the work, explanation of taxonomic characters, early stages and bionomics, especially foodplants, and the systematic placement of the family. The systematic portion encompasses 72 species in the genus *Ethmia* in addition to 4 species of uncertain placement and 4 species transferred to other taxa. In synonymizing other previously described genera, Sattler displays a sensible respect for the appreciation of problems of higher category taxonomy on a world basis. He issues a warning that questions of genera should not be answered on the basis of limited knowledge of only the European or other fauna; and he points out that introduction of new generic names inevitably implies distinctions which may not in reality exist. Among 135 species level names, type specimens of 95 were examined during this study; the 76 species which precipitated include 12 previously undescribed, 28 new synonyms, and 5 entities treated as new status at the subspecific level.

Each species is characterized by original citation, type locality, a brief diagnosis of external features and of male and female genitalia, summary of biology and early stages where known, geographical distribution, and other pertinent remarks. Morphological characters are illustrated by excellent drawings, including genital features of both sexes for all species where both are known, and by the incredibly good color paintings done by F. Gregor.

As a matter of format the literature cited is fairly brief. Synonymies consist of original citations only and do not include generic name combination changes. References to subsequent papers are in short form (author-date-page). Not all references are included in the terminal bibliography (e.g., those on p. 19), or else the system is not explained clearly. On the other hand, citations in the terminal bibliography are given in complete form and include reference to the individual species treated.

Geographical distribution summaries are based on specimens examined, with additional information from the literature clearly specified. Moreover, improbable reports are discussed and reports considered clearly false by Sattler are characterized as such. Faunistic compilations are mentioned, but not every local list is recorded.

Similarly, biological information is well documented. Life cycle and hostplant data are summarized (larvae will not be described in any of the volumes according to the preface). In an extensive tabular record of foodplants by *Ethmia* species, Sattler has attempted to verify all doubtful records and has weeded out errors. He emphasizes the need for certainty in identifications of both moth and host in listing foodplant records or other biological features. The widespread practice of uncritical copying of host lists results in a misleading picture when compilations are attempted. He gives the example of 12 citations of *Cerithe* by French, German, and Italian authors causing the impression of widespread use of this plant by *Ethmia pusiella*. In reality the records all trace back to one 1868 observation, and it actually refers to another *Ethmia*. Without Sattler's critical eye the host list would have been

impossible to interpret in assessing biological characteristics of the American fauna. Lepidopterists everywhere should take note of this critical screening of the distributional and biological records, which characteristically are passed down from generation to generation like folklore.

It is surprising that Palearctic ethmiids are so poorly known. One would not have expected a dozen undescribed species of moderate sized moths in a group as colorful as this. The biological scene is very incomplete, and Sattler points out the need for additional knowledge. For example, foodplants are known for only about 23 species (less than 33% of fauna). This is about the same as the state of knowledge in Nearctic and West Indian species, a comparable sized fauna, despite a century or so headstart by European lepidopterists. For many Palearctic species even the generation sequence is not well-known. *Ethmia lybiella* is said to lack the peculiar "anal legs" of the pupa which are characteristic of all Holarctic species groups in the genus, but the 1915 record has not been confirmed. Two species, *E. rothschildi* and *E. pseudoscythrella*, which are exceedingly rare and each known only from one sex, are likely to be diurnal moths which fly in early spring, judging from appearances and what we know of similar species in the western United States. It seems possible that they represent a diversity of overlooked species in arid parts of the Palearctic.

It was a disappointment to this reviewer that the work includes no discussion of possible phylogenetic associations and only cursory treatment of systematic relationships of the ethmiids, a matter which is by no means well defined when one looks at the world fauna of Gelechioidea. However, it can be argued that a faunal study of this nature is not the place for such speculation, and Sattler points out in the introduction that this could not be a detailed monograph owing to its forced scheduling.

An innovation in format which is bound to be well received is the cross-indexing of species references. Each species is assigned a number; there is a systematic checklist in numerical order and an alphabetical list which doubles as an index to species number, page, genitalia figures, and plate numbers. The numbers, given in brackets, also are used to identify foodplant and literature references. There is also an index to geographical places.

A major drawback to the format is the resultant cost. No effort has been made to economize. The quality of materials is excellent, the artwork and reproduction superb, and the high quality binding includes such luxuries as tricolor ribbon-markers. The work is presented in two volumes, which may be advisable for larger groups but was unnecessary for the ethmiids. Evidently in order to justify a separate plates volume, the black and white illustrations are reproduced at a much larger scale than was needed, with much wasted space (sometimes only one genitalia figure per  $10.5 \times 7.5$  inch page), with explanations on a blank opposing page rather than at the bottom of the same page. The 190 pages thus consumed could easily have been reduced to 30–40% that total without any loss of accuracy or clarity to the figures.

Provided that the authorities of Microlepidoptera Palearctica can solicit contributors capable of executing with preciseness comparable to that of Klaus Sattler, they will indeed produce the truly monumental work promised in the forward. Too often in such faunal works temptation to quickly encompass all taxa dictates lax editorial control and selection of specialists of varying ability, resulting in uneven quality from one volume to another. It will be interesting to see if the standard of discrimination and accuracy established in this treatment of Ethmiidae can be maintained.

MICROLEPIDOPTERA PALEARCTICA. VOLUME 3. COCHYLIDAE, by Josef Razowski. G. Fromme & Co., Vienna. In two bound vols.: text, xiv + 525 p.; plates, 27 color, 134 black & white, each with unnumbered expl. page facing. Sept., 1970 (Full price about \$108, subscription price data not available). [text in German]

This volume treats 291 species in 21 genera and 5 species of uncertain placement in the tortricoid family known in the past as Phaloniidae. Although Razowski has published extensively on the group previously and has catalogued the Palearctic species separately in 1970 (*Acta Zool. Cracov.*, 15: 341-399), the present work is said to contain the following nomenclatural additions and changes: 21 new species, 1 new subspecies, 14 new synonyms of genera or new status as subgenera (including 11 Razowski names), 59 new synonyms of species, 7 new status as subspecies, and 39 new combinations.

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JAMAICA AND ITS BUTTERFLIES, by F. Martin Brown and Bernard Heineman, illustrated by Marjorie Statham Favreau and others. 1972. xv + 478 p., 11 colored plates. The Curwen Press and E. W. Classey Ltd., London, England. Price: \$44.00 U.S.

This long-awaited work will be a "must" for the amateur of tropical butterflies, for the professional systematist, for those interested in the biogeography of the Americas and for all who delight in a sumptuous natural history, placed in a tropical island setting and illuminated with a wealth of human anecdotes and detailed classificatory and biological information. The book consists of a general introduction, containing historical, environmental and biological background, supplemented by personal reminiscences in Barney Heineman's inimitable style; then there is an extensive account of the biogeography of West Indian butterflies, prepared by Martin Brown, long a student of the area; the body of the book follows, consisting of detailed treatment of the 120 species, with their classification, probable history and biology; the whole is complemented by the set of beautiful and extraordinarily accurate colored plates prepared by Marjorie Statham Favreau and finely reproduced by the Curwen Press. The book as a whole reflects the brilliance and erudition of Martin Brown, the energy and detailed local knowledge of Barney Heineman and the warmly human personalities of both authors.

It would be hard to write a work of this scope without giving some grounds for criticism. To expect an individual with as many competing and compelling interests as Martin Brown, working against a deadline, to write a completely fault-free account of the classification and geography of the Antillean butterflies in the framework of the whole neotropical fauna would be asking a good deal of human nature. A number of errors or questionable interpretations are accordingly evident in the text, though they are far outweighed by the immense value and interest of the material as a whole.

I know less about West Indian butterflies than I did 25 years ago and at the time of writing I lack ready access to a good deal of the literature. Consequently I have not attempted to review the taxonomy and distribution completely, but I feel obliged to pick up a few points.

In the zoogeographic section there are a number of questionable items. The subspecies of *Calisto smintheus* are listed under the Bahaman *C. sibyla*, whose range is given as Cuba. The recent paper by de la Torre y Callejas, who has revised the Cuban populations on the basis of extensive collecting and field work, has been passed over without comment. The statements on the sedentary and forest-loving habits of Satyridae are exaggerated. Several species of *Calisto*, including the Jamaican *C. zangis*, are common in open country and some have been recorded as pests of sugar cane. The continental species of *Hermeuptychia* include forms that are ubiquitous in a wide variety of habitats, and confinement to forests is not a sufficient explanation for their failure to reach the Antilles. Though some of the Hispaniolan species and subspecies of *Calisto* are, as Brown says, closely similar, many of them are very distinct. Most of them are local and as the island has been very

superficially investigated I expect more, rather than less, species to be recognized when the fauna is fully known.

In the Lycaenidae, *Hemiargus ceraunus* is not mentioned in the table on p. 60; on p. 252-255 it is treated as a subspecies of *H. hanno*, but on p. 61 we read, "From Hispaniola and Costa Rica northward *H. hanno* is replaced by *H. ceraunus*, a good species related to *H. hanno*." Nabokov's view that the two species have separate clines in the West Indies and a zone of overlap in Hispaniola is not mentioned. In the Pieridae I consider *Ascia menciaee* to be probably no more than the Cuban subspecies of *A. josephina*. *Eurema messalina* is shown in the table as occurring in Hispaniola and Puerto Rico, whereas in the text it is correctly cited as occurring in Jamaica, Cuba and the Bahamas. *Eurema laeae*, *E. lathyi*, *E. nicippiformis*, *E. euterpiiformis*, *E. pyro* and *E. chamberlaini* are omitted without comment. The view taken by d'Almeida and by myself that *E. dina* and *E. leuce* are distinct species separable on genital characters is not mentioned, nor is the sympatric occurrence of two very distinct populations of this complex in Hispaniola. The Hispaniolan *Phoebis editha* is omitted from the table, though Brown himself first recognized and described the strikingly dimorphic, superficially *sennae*-like male. *P. avellanea* [sic] certainly occurs in Hispaniola, as does *P. philea thalestris*. I agree with the authors that this last may well be a good species rather than only a subspecies. In the Papilionidae *Battus devilliers* [sic] is listed as occurring in Hispaniola, where it is in fact replaced by the related but very distinct *B. zetides*. *Papilio polyxenes* is listed under the suppressed name *P. ajax*. *P. machaonides* is omitted.

This is not the place for detailed discussion of biogeography. I think Brown would be the first to say that many of his speculations as to dates of arrival should be taken with a grain of salt. The role of the probably emergent Honduras Banks in populating the West Indies in the Pleistocene and Tertiary seems to me to be probably underestimated, whereas the relatively recent Yucatan-Cuba immigration route is possibly given undue prominence, though it has certainly been important for the recent fauna. The existence of special Jamaican elements, consisting first of species not found elsewhere in the Antilles, but closely allied to Central American forms (e.g. *Papilio thersites*, *Anaea johnsoni* and *Mestra dorcas*) and second of segregates or duplications of widespread Antillean forms with considerable endemic differentiation (e.g. *Hemiargus dominica*, *Electrostrymon pan* and *Pyciodes proclea*) is not mentioned explicitly or specifically explained. The role of geological rifting and drift in the Antilles also deserves attention and assessment. In the comparison of total faunas, the method adopted underestimates the degree of differentiation from large faunas and overestimates that from small faunas. The fauna of Hispaniola will certainly prove to be much underestimated in Table 2, both because of the omission of a number of known species and because Hispaniola has been far less thoroughly explored entomologically than the other Greater Antilles.

The taxonomic section, with its thorough treatment of the classification and distribution of the species and groups, is of course the part of the book that provides the largest amount of detailed and often new scientific information. The extensive distributional record is a tribute to the industry both of the authors and of the other collectors whose work they so carefully summarize and document. The biogeographic and evolutionary interpretations of the various taxa are of course more speculative, and opinions on them will vary.

A rather superficial scrutiny reveals some doubtful points. I won't debate the division into families and other higher groups, as the relative ranking is really in large part a matter of personal preference. I do think the separation of Heliconiinae from Argynniinae at the family level is rather hard to justify. I would rather have seen *Battus* and *Parides* separated in the Papilionidae, for these two genera differ in really striking morphological characters. I myself also consider the New World *Eurytides* significantly different from the Old World *Graphium*; the structural differences are for instance substantially more important than those that separate

*Libytheana* from *Libythea* or *Aphrissa* from *Phoebis*. On the whole, however, I consider the generic classification moderate and well balanced.

The discussion of the Danaidae is taxonomically sound, but the biogeography suffers here as elsewhere for making dispersal contingent on mass migration. Actually the latter is often confined to males (though not so in the Danaidae), and there is abundant indirect evidence that waif dispersal of non-migratory species is a significant factor in populating islands even when they are much more strongly isolated than the Greater Antilles. In the present context, oversea dispersal of *D. eresimus* is excluded because this species is not known to be migratory, though Bates has recorded an obvious waif from the Florida Keys and the occurrence of the species is in general rather erratic and local. The detailed status of *D. plexippus* in the West Indies is still confused, though the general picture of resident populations contaminated in varying degree by migrants from the north seems clear enough. We badly need a statistical study comparable to that which Brown so competently did on *Heliconius charitonius*. The supposed subspecies of *Lycorea cleobaea* are based, to the best of my belief, on very scanty material; in my opinion they will require review. *Anetia jaegei* and *A. cubana* are treated as distinct in the text, though united in the geographic table. I agree with the former interpretation. The actual capture of an *Anetia* of this group in Jamaica is to be awaited with the keenest interest.

Mr. Gerardo Lamas M. has kindly provided me with some notes on the Ithomiidae (or Ithomiinae, as he prefers to call them). He points out that hair tufts are found on the hindwings of females as well as males, at least in some species of *Thyridia*. The type-specimen of *Papilio irene* Drury apparently is not at the University Museum, Oxford, where a search by Mr. E. Taylor has failed to reveal it. Although the general image of ithomiids as local and shade-dwelling is correct, many of the species are widely distributed, some live in open places rather than in the shade, and at least one, *Mechanitis lysimnia nessaea* (Hübner), has been recorded as a migrant (May 1924, cited by C. B. Williams, *The Migration of Butterflies*, 1930: 341). Most or all the species are highly resistant to mechanical injury, and thus might survive transport by storms. *Greta* was placed by Fox (1968) in the tribe Thyridiini. Fox did not divide *Greta* into two subgenera. Godman and Salvin in 1879 erected the new genus *Hypoleria* with two sections, A and B. These correspond today to *Hypoleria s.s.* (Section A) and *Greta* (Section B), as was stated by Fox. Fox (1968) lists seven species from Central America. The proper name of the Jamaican ithomiine appears to be *Greta diaphana* (originally *Papilio diaphanus*); *diaphane* is an unnecessary *nomen novum* given by Hübner, who thought that *diaphanus* was preoccupied.

The treatment of *Junonia* ("Precis") reflects continuing uncertainty as to the status of the forms. Thorough biological and statistical study using modern methods will be needed to resolve the problems of this group. Such a study will make a rewarding project for some future student. Ideally it will extend to the members of the Old World *orithyia* complex as well, whose relationships to *evarete* and allies were debated by Eliot and myself. The larval differences observed by Turner between *genoverva*-like and *zonalis*-like stocks in Jamaica are mentioned, but Brown and Heineman wisely await more comprehensive evidence before assessing these differences.

In the Lycaenidae the species *pan* (Drury) is placed in the text but in *Electrostrymon* in the zoogeographic table.

The authors confess themselves puzzled by Avinoff's record of *Anteos lacordairei* Boisduval. I can shed some light on this from personal recollection. Avinoff considered *lacordairei* and *maerula* to be sibling species analogous to *Kricogonia lyside* and *castalia*, which he also considered distinct. He thought *lacordairei* was a relatively scarce species which differed in the blackish not reddish antennae, shorter wing and more strongly striated underside from the more abundant *maerula*. When I was more familiar with the problem I thought this view had some merit, but



looking back I don't think the evidence was very strong. However the idea should perhaps be checked out by someone who has good material at hand.

On the Papilionidae, *Papilio troilus* has turned up once or twice as a stray in Cuba. As several sight records and speculative occurrences are discussed, I was disappointed to see no reference to Avinoff's "*Papilio arawak*" a name he used hypothetically and in conversation to refer to several sightings of a large white butterfly, not an *Anteos*, which he thought might be an unknown swallowtail. It was one of his lifelong ambitions to find and capture this butterfly and the hope should not be lost to the present generation of Jamaican lepidopterists.

There are a number of spelling lapses in both the general and the taxonomic sections of the book, for example *Sideronia* for *Siderone* (p. 52), *teleboa* for *teleboas* (p. 54, 55), *avellanada* for *avellaneda* (p. 62), *thetys* for *tethys* (p. 85, 86), *Glossypteris* for *Glossopteris* (p. 98), *exotische* for *exotischer* (p. 103, et al.), *bekannte* for *bekannter* (p. 124 et al.), *eleucha* for *eleuchea* (p. 137), *dorcus* for *dorcas* (p. 156), *Suite* for *Suites* (p. 197), *Ithoballus* for *Ithobalus* (p. 321) and André for Andrey (p. 325). The capitalization and punctuation of bibliographic references in the text are erratic. A number of relevant references are omitted from the bibliography. These include papers by Wm. P. Comstock, Eliot, Ford, Hemming, Martorell, de la Torre y Callejas and a couple by myself, among others.

These imperfections, though numerous, are in general minor. They will not seriously detract from the standing of this book as the most thorough treatment ever given to any Antillean lepidopterous fauna. Above and beyond this the book is produced in such a way that it is a collector's piece worthy of a place on any bookshelf.

EUGENE MONROE, *Entomology Research Institute, Canada Department of Agriculture, Ottawa.*

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## NOTES AND NEWS

I wish to thank the many persons who provided assistance to me during this first year of my editorship.

The members of the Editorial Committee of the Journal were most helpful as primary reviewers of submitted manuscripts. In addition, the following individuals reviewed one or more manuscripts upon request: D. E. Berube, H. K. Clench, C. V. Covell, C. D. Ferris, D. J. Klingener, A. B. Klots, A. P. Mange, W. B. Nutting, C. L. Remington, D. F. Schweitzer, A. M. Stuart, and O. R. Taylor. All of these persons performed a valuable service to the Society, and thanks are warmly extended to them.

My wife, Katherine, provided the cover drawing (*Catocala flebilis* Grote) for this volume, and aided in many other ways. Nancy Wells served as my editorial assistant throughout the year, and her invaluable help is most gratefully acknowledged. Finally, from among the many, I especially wish to thank D. F. Hardwick and S. S. Nicolay for their particular kindnesses.

THEODORE D. SARGENT

## OBITUARY

HUBERT DE LESSE (1914-1972)



One of the best-known of European lepidopterists, and a former vice-president of the Lepidopterists' Society, Hubert de Lesse, was found dead in his house in mid-March, following a period of two years of progressively failing health, with recurrent illnesses and hospitalizations.

Chief Research Scientist of the Centre national de la Recherche scientifique, and Corresponding Member of the Muséum national d'Histoire naturelle in Paris, Dr. de Lesse was well-known to professional lepidopterists through his many publications on Rhopaloceran chromosomes, as well as his systematic studies on Satyrinae and Lycaenidae. Fewer of his scientific colleagues knew of his devotion to alpinism (mountain climbing), or were aware of his extensive travels to tropical lands; his intense interest in field studies of Lepidoptera literally led him to visit the climatological "ends of the earth." These travels resulted in the gathering and publication of an uncountable number of significant observations on the zoogeography, behavior, sympatry, and interaction of butterfly species, which will modify and perfect presently accepted concepts in these areas for several generations to come.

Born in Paris on April 7, 1914, and an active member of the Société entomologique de France since 1932, Dr. de Lesse spent most of his research career successfully applying to butterfly systematics the methods of cytological analysis which he learned during two years of botanical research (1938-1939). At the end of World War II, he dedicated his

talents to a study of the satyrine genus *Erebia*, combining his love for Lepidoptera with that for mountain heights. After a trip to Greenland with the Second French Polar Expedition (1949), which resulted in a series of publications on the botany and entomology of this frozen land, he applied morphological studies of both male and female genitalia to the revision of the satyrine genera *Satyrus*, *Pararge*, *Maniola*, and *Lethe*. Continuing studies on various nymphalid groups and Lycaenidae, especially alpine forms, led to a variety of publications on these and related subjects; in the two years 1951–1952, over thirty papers appeared from his hand.

Starting in 1950, a new field—that of chromosome study—came to be more significant in the work and publications of Hubert de Lesse. During the twenty years that he devoted himself to this line of research, he established his name as one of the pioneers and principal workers in the field, publishing nearly sixty papers on the subject and its direct systematic implications. Many changes in specific and subspecific designations and relationships were introduced by his studies of chromosome numbers in various Lepidopteran groups. However, the real value of this work lay in the derived understandings of the fundamental biological processes of speciation, despeciation, hybridization, sympatric isolation and the formation of sibling species, and—in fact—evolution itself, observable as though it were a contemporary phenomenon, through examinations of cytological preparations and systematic field studies in carefully chosen localities.

His doctoral thesis, on chromosome variation and speciation in Rhopalocera, was successfully presented and defended in the Sorbonne on November 16, 1960. In the following years, Dr. de Lesse undertook extensive travels to all parts of Europe, Turkey, Iran, Libya, eastern and southern Africa, and Central and South America. He also received material fixed for chromosome study from colleagues and correspondents in North America, northern and equatorial Africa, and Madagascar.

This author had the privilege of working with Hubert de Lesse over the last two years of his life, following his visit to Brazil at the end of 1969. In joint and individual excursions during his visit, we fixed for chromosome examination and studied in the field a large number of species of Neotropical Lepidoptera, representing the families and groups already known to be most interesting for further study. Although already suffering from ill health, Dr. de Lesse showed himself to be a persistent, observant, and effective field worker, dedicating himself many hours each day to the task of studying and fixing Brazilian Rhopalocera, during a period of highly unfavorable weather conditions.

The continued deterioration of his health prevented Dr. de Lesse from bringing to fruition the large-scale project developed during this brief period of our collaboration. However, a short joint paper restricted to the examination of the material fixed during the 1969 visit has been published, and laid the basis for a forthcoming series of studies on the evolutionary significance of chromosome numbers and patterns in Neotropical Lepidoptera. The father and originator of this series unfortunately has not survived to see it come to maturity, but his careful instructions, time-tempered methods, and wise orientation will continue in the work now being carried to its conclusion in a variety of laboratories in Europe and the Americas.

Hubert de Lesse was, above all, an individualist and field naturalist, happiest in the isolation of alpine meadows or tropical forests, far from the urban noise and population pressure of his home city. However, he constrained himself to spending long hours in his flower-surrounded Paris house on rue de l'Est (Reuil-Malmaison), searching for, drawing, and studying, under a microscope at over a thousand magnifications, tiny bits of concentrated biological and evolutionary information. The result of this painstaking sacrifice, which took a progressive toll on his vision, nerves, and general health, is a legacy of suggestive and authoritative publications, which will serve the world community of lepidopterists and biologists in general for many years in the future.

Dr. de Lesse's extensive collections are in the Entomological Laboratory of the Muséum national, in Paris. A selected list, including the more significant of his 137 publications, conserving original numbers in the complete list, follows:

2. Contribution à l'étude du genre *Erebia*. Rev. Fr. de Lépid. 11: 97-118 (1947).
4. *Hipparchia fagi* Scop. et *H. aelia* Hffmsg. Bull. Soc. Lin. Lyon n° 7: 123-129 (1948).
5. Contribution à l'étude des Rhopalocères du département de la Drôme. Lambillionea 48: 59-64 (1948); 49: 8-30 (1949).
8. Contribution à l'étude du genre *Coenonympha*. Lambillionea 49: 68-80 (1949).
10. Contribution à l'étude du genre *Erebia*: armures génitales femelles. Rev. Fr. d'Entomol. 16: 165-198 (1949).
11. Expéditions polaires françaises. Zoologie. Première note: Microlepidoptera (in collaboration with P. Viette). Ann. Soc. Entomol. France 115 (1946), 81-92 (1949).
13. Observations sur les Lépidoptères du Groenland, et remarques sur leur homochromie. Rev. Fr. de Lépid. 12: 163-169 (1949).
14. Quelques indications sur *Melitaea britomartis* Assm., espèce à rechercher en France. Bull. Soc. Lin. Lyon n° 2: 38-41 (1950).
17. Notes zoologiques et botaniques sur l'Ouest du Groenland. La Terre et la Vie n° 4: 175-201 (1950).
18. Expéditions polaires françaises. Zoologie. 4<sup>e</sup> note: Macrolepidoptera. Ann. Soc. Entomol. France 118 (1948), 51-78 (1951).

21. Sur une espèce de Satyridae mal connue: *Hipparchia* (*Pseudotergumia*) *wyssii* Christ. Bull. Soc. Entomol. France n° 4: 50-53 (1951).
23. Divisions génériques et subgénériques des anciens genres *Satyrus* et *Eumenis* (*s.l.*). Rev. Fr. de Lépid. 13: 39-42 (1951).
24. Quelques Lépidoptères de Besse en Chandesse (in collaboration with P. Viette). Rev. Fr. de Lépid. 13: 78-83 (1951).
25. Contribution à l'étude du genre *Erebia* (3° note). Répartition dans les Pyrénées de *E. tyndarus* Esp. et *E. cassioides* Rein. et Hohenw. Vie et Mileau 2: 95-123 (1951).
27. Contribution à l'étude du genre *Erebia* (4° note). Répartition de *E. pandrose* (Borkh.) et de sa sous-espèce *sthennyo* Grasl. dans les Pyrénées. Vie et Mileau 2: 267-277 (1951).
28. Les types de Nymphalidae paléarctiques du Laboratoire d'Entomologie du Muséum d'Histoire Naturelle de Paris (in collaboration with G. Bernardi). Bull. Soc. Entomol. France n° 9: 136-143 (1951).
31. Révision de l'ancien genre *Satyrus*. Ann. Soc. Entomol. France 120: 77-101 (1951).
32. Expéditions polaires francaises. Zoologie (6° note). Biogéographie des Lépidoptères du Groenland. Ann. Soc. Entomol. France 119: 97-116 (1951).
33. Contribution à l'étude du genre *Erebia* (6° note). Notes de répartition et nouvelles indications sur *E. eriphyle* (Frr.) et *E. stirius* (Godt.) récemment signalés de France. Rev. Fr. de Lépid. 13: 130-137 (1951).
34. Un Rhopalocère de plus à inscrire au Catalogue des Lépidoptères de France—*Euphydryas ichnea* Bdv. (= *intermedia* Mén.) (Nymphalidae). Rev. Fr. de Lépid. 13: 143-152 (1951).
36. Note sur les genres *Precis* Hb. et *Junonia* Hb. (Lep. Nymphalidae). Bull. Soc. Entomol. France 57: 74-77 (1952).
37. La variabilité géographique de *Lycaena helle* Denis et Schiff. (Lep. Lycaenidae) (in collaboration with G. Bernardi). Rev. Fr. de Lépid. 13: 203-213 (1952).
41. Liste des Grypocères et Rhopalocères de la Faune française conforme aux Règles internationales de la Nomenclature. Satyridae (Rev. Fr. de Lépid. 13: 241-245 (1952).
43. Révision des anciens genres *Pararge* (*s.l.*) et *Maniola* (= *Epinephele* auct.). Ann. Soc. Entomol. France 121: 61-76 (1952).
44. Cytologie—Quelques formules chromosomiques chez les Lycaenidae (Lépidoptères Rhopalocères). Comptes Rendus Acad. Sci. 235: 1692-1694 (1952).
47. Révision des *Neohipparchia* (Lep. Satyridae) d'Afrique du Nord. Bull. Soc. Sci. Nat. Maroc. 32: 91-105 (1952).
48. Formules chromosomiques nouvelles du genre *Erebia* (Lepid. Rhopal.) et séparation d'une espèce méconnue. Comptes Rendus Acad. Sci. 236: 630-632 (1953).
50. Formules chromosomiques de *Boloria aquilonaris* Stichel, *B. pales* D. et Schiff., *B. napaea* Hoffmsg. et quelques autres Lépidoptères Rhopalocères. Rev. Fr. de Lépid. 14: 24-26 (1953).
53. Formules chromosomiques nouvelles chez les Lycaenidae (Lepid. Rhopal.). Comptes Rendus Acad. Sci. 237: 1781-1783 (1953).
54. Les types de Nymphalidae paléarctiques du Laboratoire d'Entomologie du Muséum d'Histoire Naturelle de Paris (2° note). (in collaboration with G. Bernardi). Bull. Soc. Entomol. France 58: 154-160 (1953).
55. Recherches cytologiques et biogéographiques sur quelques Lépidoptères. Bull. Soc. Zool. France 78: 287-291 (1953).
56. Découverte d'un nouvel *Erebia* dans les Hautes-Pyrénées (in collaboration with H. Descimon). Rev. Fr. de Lépid. 14: 119-122 (1953).

57. Formules chromosomiques nouvelles chez les *Lycaenidae* (Lepid. Rhopal.). Comptes Rendus Acad. Sci. 238: 514-516 (1954).
58. Discussion de certains caractères morphologiques d'*Arethusana arethus* Schiff. et des formes *boabdil* Rambur et *dentata* Stgr. Rev. Fr. de Lépid. 14: 140-142 (1954).
59. Comments on two recent papers on the genus *Erebia*: a reply. The Entomologist 87: 91-96 (1954).
60. Expériences de croisements dans le genre *Erebia* (Lépidoptères Satyridae) (in collaboration with Z. Lorkovic). Bull. Soc. Zool. France 79: 32-39 (1954).
61. Contribution à l'étude du genre *Erebia* (12<sup>e</sup> note). Description des premiers états. Rev. Fr. de Lépid. 14: 167-179 (1954).
62. Nouvelles découvertes concernant le degré de parenté d'*Erebia tyndarus* Esp. et *E. cassioides* Hohenw. (in collaboration with Z. Lorkovic). Lambillionea 54: 58-68 and 78-86 (1954).
63. Etat actuel de la systématique du groupe d'*Erebia tyndarus* Esp. (*s.l.*). Etude d'un travail récent. Rev. Fr. de Lépid. 14: 228-236 (1954).
65. Contribution à l'étude du genre *Erebia* (13<sup>e</sup> note). Description des premiers états. Rev. Fr. de Lépid. 14: 251-257 (1954).
67. Recherches de formules chromosomiques chez les *Zygaena*. Bull. Soc. Lin. Lyon 24: 142-144 (1955).
68. Distribution holarctique d'un groupe d'espèces du genre *Erebia* (Lépidoptères) récemment séparées d'après leurs formules chromosomiques. Comptes Rendus Soc. Biogéogr. 276: 12-18 (1955).
71. Note supplémentaire sur le groupe d'*Erebia tyndarus* Esp. (in collaboration with Z. Lorkovic). Lambillionea 55: 55-58 (1955).
72. Etude cytologique des *Lysandra* fixés par M. H. Beuret. Mitt. Entomol. Ges. Basel, 77-80 (1953).
73. Quinze jours de récoltes en Italie centrale et découverte d'*Erebia pandrose* Bkh. aux Monti della Laga. Lambillionea 56: 9-16 (1956).
74. Notes on the species groups in the genus *Erebia*: a reply. The Entomologist 89: 278-282 (1956).
75. Fixation de lectotypes et description d'une nouvelle sous-espèce dans le groupe d'*Erebia tyndarus* Esp. (Lepid. Nymphalidae Satyrinae). Rev. Fr. de Lépid. 15: 147-150 (1956).
76. Révision du genre *Lethe* (*s.l.*) (Lep. Nymphalidae Satyrinae). Ann. Soc. Entomol. France 125: 75-95 (1957).
79. Liste des Lépidoptères Rhopalocères récoltés en 1955 au Liban par H. de Lesse. Introduction, Hesperidae, Nymphalidae. Bull. Soc. Lin. Lyon 26: 238-241 (1957).
80. Une nouvelle forme de *Boloria* aux Alpes Pontiques (in collaboration with A. Crosson du Cormier). Lambillionea 57: 34-57 (1957).
81. Description de deux nouvelles espèces d'*Agrodiaetus* (Lep. Lycaenidae) séparées à la suite de la découverte de leurs formules chromosomiques. Lambillionea 57: 65-71 (1957).
85. Lépidoptères Rhopalocères récoltés en Iran. Introduction. Alexanor 1: 39-46 (1959).
86. Séparation spécifique d'un *Lysandra* d'Afrique du Nord à la suite de la découverte de sa formule chromosomique. Alexanor 1: 61-64 (1959).
87. Caractères et répartitions en France d'*Erebia aethiopellus* Hoffmsg. et *E. mnestra* Hb. Alexanor 1: 71-81 (1959).
88. Caractères externes et formule chromosomique d'*Agrodiaetus baytopi* n. sp. (Lep. Lycaenidae). Bull. Soc. Ent. Mulhouse, 45-48 (1959).
90. Note sur deux sous-espèces d'*Agrodiaetus* (Lep. Lycaenidae) récemment séparées d'après leurs formules chromosomiques. Lambillionea 59: 5-10 (1959).

91. Nouvelle étude chorologique et cytologique conduisant à changer l'application du nom d'*Agrodiaetus iphigenia* H.S. (Lep. Lycaenidae). Lambillionea 59: 57-61 (1959).
92. Les nombres de chromosomes dans la classification du groupe d'*Agrodiaetus ripartii* Freyer (Lepidoptera, Lycaenidae). Rev. Fr. d'Entomol. 27: 240-264 (1960).
93. Recherches sur la distribution des représentants du groupe d'*Erebia tyndarus* Esper. *Erebia calcarius* au Monte Cavallo au nord de Venise (in collaboration with Z. Lorkovic). Bollet. Soc. Entomol. Ital. 90: 123-129 (1960).
95. Spéciation et variation chromosomique chez les Lépidoptères Rhopalocères. Ann. Sci. Nat., Zool. 1: 1-223 (1960). Doctoral thesis defended in the Sorbonne on November 16, 1960.
98. Les hybrides naturels entre *Lysandra coridon* Poda et *L. bellargus* Rott. Alexanor 2: 22-30 (1961).
99. Variations géographiques des caractères externes chez les espèces autrefois réunies sous le nom d'*Agrodiaetus ripartii* Frey (Lep. Lycaenidae). Rev. Fr. d'Entomol. 28: 93-100 (1961).
100. Les nombres de chromosomes chez *Agrodiaetus dolus* Hb. et les espèces voisines. Alexanor 2: 57-63 (1961).
101. Signification supraspécifique des formules chromosomiques chez les Lépidoptères. Bull. Soc. Entomol. France 66: 71-83 (1961).
102. Deux nouvelles formules chromosomiques où *n* dépasse 100 chez les Lycaenidae (Lépidoptères Rhopalocères). Comptes Rendus Acad. Sci. 253: 1982-1984 (1961).
103. Variation chromosomique chez *Agrodiaetus actis* H.S. et *A. altivagans* Forst. Rev. Fr. d'Entomol. 29: 66-75 (1962).
104. Formules chromosomiques de quelques Lépidoptères Rhopalocères du Sénégal (in collaboration with M. Condamin). Bull. I.F.A.N. 24 A: 464-473 (1962).
107. Lépidoptères Lycaenidae récoltés en Iran en 1961. Alexanor 2: 305-312 (1962); 3, 33-38 (1963).
109. Variation chromosomique chez les *Agrodiaetus* (Lep. Lycaenidae). Rev. Fr. d'Entomol. 30: 182-189 (1963).
110. Nomenclature des *Erebia* français. Alexanor 3: 127-136 (1963).
112. Les nombres de chromosomes chez quelques *Erebia* femelles (Lep. Satyrinae). Rev. Fr. d'Entomol. 31: 112-115 (1964).
113. Formules chromosomiques de quelques Lépidoptères Rhopalocères du Gabon (in collaboration with G. Bernardi). Biologica Gabonica 1: 65-71 (1964).
114. Formules chromosomiques de quelques Lépidoptères Rhopalocères du Sénégal et de Côte d'Ivoire (in collaboration with M. Condamin). Bull. I.F.A.N. 27: 1089-1094 (1965).
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117. Formules chromosomiques de quelques Lépidoptères Rhopalocères d'Afrique Centrale. Ann. Soc. Entomol. France, N.S. 2: 97-101 (1966).
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123. Formules chromosomiques de Lépidoptères Rhopalocères d'Uganda et du Kenya. Ann. Soc. Entomol. France, N.S. 4: 581-599 (1968).
124. Les hybrides naturels de *Lysandra coridon* Poda et *Lysandra bellargus* Rott. (2° note). Alexanor 6: 73-82 (1969).
125. Les nombres de chromosomes dans le groupe de *Lysandra coridon* Poda. Ann. Soc. Entomol. France, N.S. 5: 469-522 (1969).

127. Quelques nombres de chorosomes de Lépidoptères Rhopalocères d'Amerique du Nord. Bull. Soc. Entomol. France 74: 57-58 (1969).
128. Les nombres de chromosomes chez les Lépidoptères Rhopalocères em Amérique centrale et Colombie. Ann. Soc. Entomol. France, N.S. 6: 347-356 (1970).
130. Systématique du groupe de *Lysandra coridon* (Lep. Lycaenidae). Alexanor 6: 203-224 (1970).
131. Formules chromosomiques de quelques Lépidoptères Rhopalocères de Guyane. Ann. Soc. Entomol. France, N.S. 6: 849-855 (1970).
134. Une nouvelle sous-espèce de *Melanargia galathea* L. (Lep. Nymphalidae Satyrinae). Alexanor 7: 156-157 (1971).
135. Formules chromosomiques de Lépidoptères Rhopalocères du Brésil (in collaboration with K. S. Brown, Jr.). Bull. Soc. Entomol. France 76: 131-137 (1971).
136. Variations géographiques des nombres chromosomiques chez les Lycaenidae. Comptes Rendus Soc. Biogéogr. 48 (407-421): 33-38 (1972).
137. Formules chromosomiques de Lépidoptères Rhopalocères de Madagascar. Bull. Soc. Entomol. France 77, in press (1972).

#### ACKNOWLEDGMENTS

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KEITH S. BROWN, JR., *Centro de Pesquisas de Produtos Naturais, U.F.R.J., Rio de Janeiro, Brazil.*



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by CYRIL F. DOS PASSOS

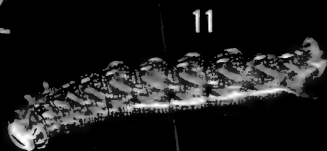
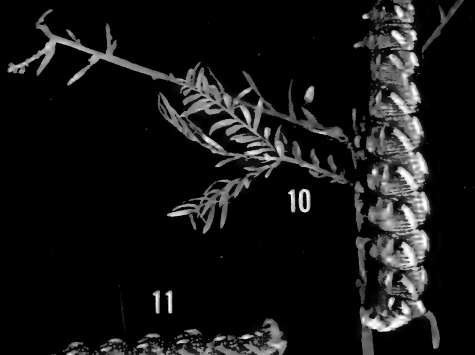
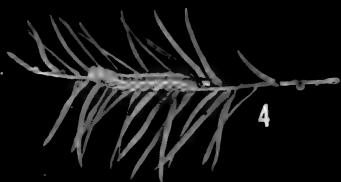
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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## LIFE HISTORY OF *ISOPARCE CUPRESSI* (SPHINGIDAE)

RICHARD B. DOMINICK

The Charleston Museum, Charleston, South Carolina 29401

References to the life history of *Isoparce cupressi* (Boisduval), the Cypress Sphinx, are scarce in the literature. The only description of the larva known to the author is that by Bates (1928) referred to by Hodges (1971). The adult moth has been taken with regularity in coastal South Carolina at light in the neighborhood of its food plant, Bald Cypress (*Taxodium distichum* (L)). Two main broods occur in this area, the spring brood from mid-March through mid-May with a high peak in April, and the second brood predominately during August and September. A scattering of specimens is also taken during all the summer months. Hodges (1971) has given an excellent description of the adult moth, but one further distinctive feature should be mentioned. Just to the costal side of the heavier broken black dash on the forewing, at about the center of the wing surface, is a reddish brown streak running parallel with and adjacent to the black dash. This marking, together with the black dash (there are often two or three of the latter), is quite conspicuous and diagnostic in the fresh specimen.

On 13 August 1971 at McClellanville, South Carolina a female *Isoparce cupressi* was captured at a mercury vapor light, labelled ♀ A71, and permitted to lay eggs in captivity. She did so without hesitation, laying approximately one hundred eggs, first on paper in a plastic box and later

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←

Color Plate. *Isoparce cupressi* (Bdv.) and its foodplant (*Taxodium distichum*) (natural size). 1. Adult ♂, caught at light 13 Sept. 1968; 2. 2nd instar larva, 5 days old; 3. 3rd instar larva, 11 days old; 4. 3rd instar larva, 10 days old; 5. 4th instar larva, 13 days old; 6. 4th instar larva, 14 days old; 7. 5th instar larva, 3 weeks old, full grown; 8. pupa, 1 week old, ex larva placed on wild cypress tree; 9. and 10. 5th instar larvae, 3 weeks old, full grown; 11. 5th instar larva, 3 weeks old, about to pupate. (All larvae are freeze-dried specimens.)

on sprigs of cypress introduced for her benefit. Being confined to a small area, of course, a natural pattern of egg-laying could not be definitely determined; however the eggs were laid singly rather than in clusters, and when the fresh cypress was presented she chose to lay singly on the plant. The eggs are slightly flattened spheres 1 mm in diameter, grossly smooth, microscopically very slightly and evenly roughened, and of a pearly green color. The micropyle appears to lie dorsolaterally. The larva hatches in seven days, leaving a transparent uneaten eggshell. We killed our female after three days. No food was presented as it is a superfluous commodity for a moth with rudimentary mouthparts.

### Larval Instars

Coloration and markings of the larvae through the successive instars progress as a model of camouflage on their food plant. The first instar larva is green and at one day old is about 3 to 4 mm in length, with a black dorsal horn about 3 mm long. The head is round, green and immaculate. A dorsal and two lateral stripes, one on each side, extend the length of the caterpillar except for the prothoracic segment where they fade toward the head. These three stripes are of a slightly darker green. Very thin paler bands run transversely over the dorsal surface from one lateral stripe to the other, marking off the segments. The result is a tiny larva just about the size of one of the pinnae of the young shoots of the cypress, and the larval variation of greens blends beautifully with a lengthwise position on one of the leaflets.

The second instar occurs about four days later and the larva grows to about 10 mm in length. The basic body color is a forest green, while the head acquires a pair of yellowish-green vertical stripes down each side and a similar but thinner pair down the center line. These stripes diverge somewhat from the top of the head where they commence at the base of a pair of tiny hornlike protuberances. On all segments of the body a dorsolateral and a ventrolateral stripe of a yellowish cast develop, these stripes becoming slightly constricted at the juncture of the segments and just beginning to show signs of segmental angling posteriorly toward the median. The first thoracic segment resembles the top of the head in tending to define a rather sharp angle dorsally. At this stage the first whitish lateral lunules appear, running obliquely posterodorsally from the mesothoracic segment to and including the seventh abdominal segment. On the prothoracic segment, the lunule is replaced by a horizontal white dash which continues posteriorly, fading and connecting the tops of the successive lunules. On the first thoracic segment it remains a distinctive mark throughout the succeeding instars. The horn, on the eighth ab-

dominal segment, has a roughened surface, a touch of red to its predominately black color, and is about 4 mm in length.

The third instar occurs in about another four days. For that matter, four or five days proved to be the average for each of the stadia. The pattern of the head shows no significant change. The stripes on the body remain in the same general pattern, but the longitudinal yellowish stripes are now more broken with each segment; the dorsolateral pair assume a slightly oblique aspect on each segment, slanting even more toward the median posteriorly. At this time a reddish spot appears at the site of the spiracle on each segment except for the second and third thoracic segments. The second thoracic spiracle shows instead a small black spot with one or two tiny white punctae, and that of the metathoracic segment tends to be featureless. The junction of the lateral oblique lunules (which are now acquiring the yellowish tinge of the other markings) and the ventrolateral broken stripes is now forming the shape of an arrowhead pointing cephalad on each segment, with the colored spiracular dot at the point of the arrow. It is during this third instar that the forest green of the dorsal surface begins to change to a red-brown (later darkening to a purple-brown) dorsal stripe that is a conspicuous character of the larva from this period on. It characterizes a camouflage consistent with the growth stage when the larva travels by way of the brown twigs of the cypress, and this stripe down the back with the oblique yellow-white markings on the green base color assumes the pattern of light through the foliage. This dark dorsal stripe begins on about the mesothorax and extends posteriorly onto the horn. The larva is also just beginning to show signs of developing the tiny yellow punctae that will appear more markedly later on, adding to the broken-light pattern. These spots first appear anteriorly. At the end of this instar the larva is about 18 mm long, and the posterior horn recurves slightly. The thoracic legs also gradually change color from green to reddish brown as the larva grows.

The fourth instar begins roughly two weeks after hatching. The head acquires a pair of black lines diverging downward from the upper pointed "horns" and ending about two-thirds of the way down the face. All the prolegs, including the anal, now acquire the red-brown color of the spiracles. The metathoracic spiracle may or may not have a reddish punctum; if so, it remains less conspicuous than the others. The small yellowish punctate excrescences now appear on all body surfaces. The yellowish ventrolateral segmental markings are by now well broken up by segments, and tend to disappear from the second thoracic to a variable number of segments between the mesothoracic and anterior abdominal segments. The dorsal markings are now more purplish-brown and are

punctuated by rows of minute whitish dots, while the spiracular color remains reddish as does the base and dorsum of the horn. The horn is now beset with spicules. The dorsal brown stripe takes on a newly developing shape. Beginning with the mesothorax the purplish brown of each segment has the shape of a half hourglass with the thin end behind. This is laterally edged by a touch of black and in turn with the remains of the broken yellowish dorsolateral stripe. The first thoracic segment follows the general pattern but presents a different appearance because the dorsal brown, having disappeared here, is replaced by a thin black mark flanked by the yellow and in turn by a pair of new black spots, flanked yet again by the yellow line first seen in the second instar which is in reality the lateral lunule pointing anteroposteriorly. By the end of the fourth instar the larva has reached a length of about 3 cm or slightly less. One freeze-dried specimen (not illustrated) just shedding into the fifth instar is marked as being 16 days old.

The fifth instar larva continues rapid growth to a length of about 5 cm, with the posterior horn measuring slightly under 1 cm. The abdominal spiracles and the dorsolateral surface of the prolegs become partially dark brown to blackish; the second thoracic spiracle tends to maintain its dark color with white punctae; and the rest of the spiracular coloration assumes some black along with the red-brown, that of the metathorax tending to remain relatively modest. The yellow punctate excrescences have become more numerous, following to some extent the direction of the yellow lines and lunules. These latter acquire traces of brown or black edgings. Posterior to the eighth abdominal segment (i.e., abaft the horn), the lateral spiracular brown ceases and the yellow lateral lunule straightens out to run posteriorly down and across the anal plate where it meets its mate. Some of these lines and lunules may be more white than yellow. The anal plate is greyish green dotted with tiny black spots. All in all we have an extremely handsome caterpillar, camouflaged in such a way as to be very difficult to detect on a wild cypress.

According to Bates (1928) the larvae feed at night. I was able neither to confirm nor deny this observation since this brood from ♀ A'71 was reared in confined and therefore artificial quarters and demonstrated no meal-time preferences.

#### Pupating Habits

At the end of approximately three weeks the larvae turn a purplish brown color all over and begin to wander in preparation for pupation. This color suits them well for travelling more openly on the larger branches and trunk of the tree. Their pupating habits, being for all practical purposes unknown, were of especial interest, and I endeavored

to simulate natural conditions as well as possible with some interesting, and at times perplexing and amusing results.

Three sets of conditions seemed indicated in order to discover the actions of a *cupressi* larva seeking to pupate. First was the simulation of a cypress tree standing in the water, described herein as the "water cage." Second, the simulation of a cypress growing on dry land, described as the "ground cage." Third, taking a larva directly out to a wild cypress pond and hoping for the best.

The "water cage" was made by cutting a cypress branch about two feet long and 2½ inches in diameter and suspending it by a thread from the top of a cage with its bottom end submerged in a can of water. Such a branch is quite smooth, and in order to create the likeness of a crevice or two, a couple of branching twigs were tied to the side of the limb. A smear of vaseline was applied to the suspending thread to discourage the caterpillar from climbing off the wood. The "ground cage" was made by filling a large coffee can with fine sand covered with a couple of inches of peat moss, and a similar-sized cypress branch with twigs was stuck upright into the center of the can. Vaseline was smeared around the edges of the can to discourage wandering out of the allotted area. In all, seven pupating *cupressi* larvae were used, six in the cages and one reserved for the wild.

Larva #1, on 12 September, was placed on the bark of the "water cage." It climbed up and down the eighteen inches or so of available dry trunk several times, being turned at the top by the vaseline on the thread and at the bottom by the water. It was not averse, however, to dunking its head quite thoroughly into the water before turning back. After a while it began to settle into one of the slight crevices provided by a twig, but after an hour or so of trying to snuggle in was evidently not satisfied and wandered off again, whereupon it fell into the water and drowned.

Larva #2 on the same date was put on the cypress in the "ground cage." This one was observed for twenty minutes or so crawling all about the "tree trunk" and then curled up on the top of the stump and to all appearances took a nap. At this point I was called away for about ten minutes, and upon my return there was no sign of the larva. There was no possible route of escape from the cage, and subsequent investigation proved that it had descended the "tree" and burrowed underground where it proceeded to pupate.

The next day, 13 September, three more larvae were ready to pupate. Larva #3 was put in the "water cage" and it wasted very little time indeed before either crawling or falling into the water when I had my head turned for just a moment. This time rescue was prompt and the cater-



Fig. 1. The author points to spot where larva #7 pupated. Photo by C. R. Edwards, 26 Sept. 1971.

pillar was put into the "ground cage," where it immediately crawled down the trunk and burrowed straight into the peat moss. Larvae #s 4 and 5 were then put directly into the "ground cage," and neither spent more than fifteen or twenty minutes before burrowing underground. The sand of course in this cage was packed tightly enough to support the cypress limb firmly, and the peat was fairly loose on top, but an average of only thirty seconds was required for each larva to disappear completely.

Since the "water cage" seemed a fatal hazard, I then compromised and replaced the water with sand and peat, inserting the trunk in a manner similar to the "ground cage," but in this case greasing the bottom two inches of exposed trunk with vaseline, hoping to discourage headlong downward progress but providing a safe landing just in case. Caterpillar #6 was then put on the trunk and was observed to head downward, hardly hesitating at the greased bottom. Crawling right over the vaseline, it too disappeared rapidly underground. One week later I carefully spooned out the peat and sand and found #6 had pupated in a slightly packed chamber about three inches below the surface, in the sand. There was no evident sign of silk spinning.

Larva #7 was ready to pupate on 15 September. This was the one



reserved for the wild, and was taken to a nearby cypress pond. A smallish cypress about a foot or two in diameter that was standing in the water having been selected, the larva was placed on the trunk about breast high and left to its own devices. A smallish tree such as this has relatively smooth bark, and this particular tree was chosen for a relative paucity of crannies, moss or other hiding places. This larva crawled all about and twice tried to dig into some small patches of moss, but it was evident they did not offer the protection it desired. After an hour or so of being left to explore this tree, it was transferred to a neighboring tree which offered greater chances of concealment by way of crevices and heavier patches of moss. It was interesting to note a determined attempt on the part of the larva to burrow into one mossy niche which was almost but not quite deep enough to hide it completely. The power of forcing its way into tight corners and under quite thickly rooted moss, and its evident strong desire to burrow, were noteworthy. After a half hour's attempt the caterpillar gave up and went off in search of a better spot. It found one to its satisfaction a short distance away in a patch of moss thick and deep enough to permit its burying itself completely out of sight. I marked the spot and returned a week later, and then carefully peeling back the moss, found the pupa deep in a mossy cell, smoothly shaped but again with little or no appreciable sign of spinning (Fig. 1).

These observations would seem to indicate a strong burrowing instinct on the part of the pupating *cupressi* larvae, and would explain the great difficulty of successfully searching for pupae in the wild, but will perhaps give an indication of where and how to look. The two cases of larvae falling into the water reported here can possibly be best explained by the artificial conditions imposed with insufficient room for manoeuver.

Hodges (1971) mentioned two *cupressi* pupae found by this author the previous year. These were in fact found in a remarkable and unique tract of very old virgin cypress, of the type known to the lumber industry as "Black Cypress" and noted for its fine quality. It is a tract of swampland known as Four Holes Swamp, consisting of less than 3000 acres of uncut timber near Summerville, South Carolina. It is one of the last two tracts of such trees left in the Southeast, and an urgent conservation measure is under way in an attempt to save this remnant of the past where the trees are several hundred years old and some measure over ten feet in diameter above the massive buttress. Great shards of bark hang loosely from the towering trunks, and a day's canoeing through this magnificent primeval swampland forest is an experience to stir the blood. Brown water snakes and alligators abound, or an otter may be seen gazing with inquisitive whiskers aslant before gliding silently under the dark waters. A full day of examination of every cypress within reach produced the two pupae mentioned by Hodges, tucked under the protection of loosely hanging bark. As with those reared, neither pupa of that day showed any indication of having spun.

Of the reared brood of larvae ex ♀ A'71, a goodly number were preserved in the various instars by the technique of freeze-drying, some of

which are shown in the illustration. Two of the six pupae (remember one larva drowned) were likewise preserved whole, and four adult *cupressi* moths emerged under indoor conditions in early October. The pupal cases of these latter were unearthed from the sand in the cages, and were all found at approximately the same depth and in the same type of cells as mentioned above.

The pupa is dark brown, about 3.5 cm in length and on the moderately slender side. It lacks a free tongue case. Its surface is punctate on all sides, though ventrally the abdominal segments are smooth posteriorly. It should be noted in passing that while our pupae agree in description with that given by Bates (1928) except for the placement of the punctae, none of our reared larvae reached the length quoted by that authority of 65 mm, though the four emerging adults were of normal size.

#### ACKNOWLEDGMENT

I wish to extend my thanks to Dr. Ronald W. Hodges, who has read the manuscript, offered helpful suggestions, and shuffled many commas.

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## BEHAVIORAL ADAPTATIONS OF CRYPTIC MOTHS. VI. FURTHER EXPERIMENTAL STUDIES ON BARK-LIKE SPECIES

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Prior studies have demonstrated that a number of bark-like moths will select appropriate backgrounds in various experimental apparatuses which provide a choice of backgrounds differing in reflectance (Kettlewell, 1955; Sargent, 1966; Sargent & Keiper, 1969). Several experiments indicate that these selections are based on innate preferences of the moths for certain background reflectances (Sargent, 1968, 1969a, b).

The present paper summarizes additional experiments which shed light on (1) some factors promoting "errors" in the background selections of

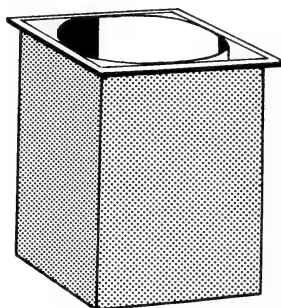


Fig. 1. The experimental apparatus used in the present studies.

moths in experimental situations, and (2) the nature of the background selection process itself. The experiments were carried out during the summers of 1970 and 1971 in Leverett, Franklin County, Massachusetts.

### General Methods and Materials

The basic apparatus in all of the experiments consisted of a cylinder (19 in. high  $\times$  44 in. circumference) made up of blotting paper sections, set into a plywood box (19 in. high  $\times$  15 in. square), and covered with a pane of window glass (Fig. 1). The blotting paper sections were painted black, gray, or white, and so provided a choice of backgrounds differing in reflectance. (The percentage-reflectance values of the backgrounds, as measured with a General Electric recording spectrophotometer against a white standard of pressed BaSO<sub>4</sub>, were: black 4.30, gray 39.50, and white 85.61.) The apparatus was placed in a wooded area, and moths were introduced into the cylinder at night by sliding the glass top to one side. Background selections of the moths were noted shortly after dawn on the following morning.

### The Experiments and Results

EXPERIMENT 1. Early observations suggested that some species which are known to select appropriate backgrounds in nature (e.g. *Catocala relict*a Walker (Noctuidae) which prefers to rest on white birch trees: Keiper, 1968; Sargent & Keiper, 1969) did not exhibit background preferences in the present experimental apparatus. It was noted, however, that the background selections of these moths might vary according to their position in the apparatus, as moths resting at the very top of the cylinder, i.e. immediately adjacent to the pane of glass, were very often over an inappropriate background. Therefore an experiment was conducted, using reared *Catocala relict*a (Sargent, 1972), in which the precise posi-

TABLE 1. Experiment 1: Background selections of *Catocala relictæ*.

Position within Cylinder	Number of Moths		P*
	White Background	Black Background	
At Top	7	8	> 0.90
Below Top	10	0	< 0.01

\* Based on chi-square tests of goodness-of-fit to a 1:1 distribution.

tions of the moths, as well as the background selections, were recorded. The experimental cylinder for this experiment consisted of alternating black and white sections (each  $11 \times 19$  in.).

The results of this experiment (Table 1) clearly revealed that moths resting at the top of the cylinder did not exhibit a background preference, while moths resting at lower levels preferred the white backgrounds. It would appear that some behavior, perhaps a phototactic or geotactic escape response, interfered with the background selections of certain moths in this experimental situation.

EXPERIMENT 2. Another factor which seemed to influence background selections in the experimental apparatus was the number of moths tested on any given night. Accordingly, a simple experiment was conducted with *Phigalia titea* (Cramer) (Geometridae), a species known to prefer pale backgrounds (Sargent, 1969b). In this experiment, tests of background selections were carried out using samples of from 1–30 individuals in the experimental apparatus. The moths were collected at lights, and the experimental cylinder in this case consisted of a white, gray, and black section (each  $14.7 \times 19$  in.).

The results of this experiment (Table 2) showed that there was a critical sample size of about 20 individuals, below which a background preference was clearly exhibited, and above which no background preference was shown. This finding suggests that some behavioral interaction,

TABLE 2. Experiment 2: Background selections of *Phigalia titea*.

Sample Size	No. Tests	Number of Moths			P*
		White Background	Gray Background	Black Background	
1–10	9	18	7	8	< 0.05
11–20	3	21	10	7	< 0.02
21–30	2	19	19	15	> 0.70

\* Based on chi-square tests of goodness-of-fit to a 1:1:1 distribution.

TABLE 3. Experiment 3: Background selections of *Cosymbia pendulinaria*.

Experimental Condition	Number of Moths		P*
	White Background	Black Background	
Without Acetate Cylinder	55	6	< 0.001
With Acetate Cylinder	30	2	< 0.001

\* Based on chi-square tests of goodness-of-fit to a 1:1 distribution.

presumably one resulting from the mutual intolerance of individuals and functioning to disperse the moths, interfered with background selections at high densities in this experimental apparatus.

EXPERIMENT 3. Some question has been raised about the ability of bark-like moths to select appropriate backgrounds from a distance, i.e. when not in direct physical contact with a substrate (e.g. Kettlewell, 1955; Ford, 1964). If contact were required, then it might be argued that thermal, rather than visual, cues were playing the important role in background selections. In that event, moths would be detecting and responding to small, surface temperature differences associated with backgrounds of different reflectances.

In order to test this possibility, the experimental apparatus was equipped with a cylinder of clear cellulose acetate which could be set within the cylinder of blotting paper sections, and which separated experimental moths from the painted backgrounds by approximately two inches. The species tested was *Cosymbia pendulinaria* Gueneé (Geometridae), which prefers white backgrounds (Sargent, 1968). The painted cylinder in this experiment consisted of alternating black and white sections (each 11 × 19 in.), and moths were tested for background preferences when the acetate cylinder was absent (controls) and present (experimentals). It was assumed that the separation of moths and backgrounds by the acetate cylinder was sufficient to prevent detection of any surface temperature differences.

The results of this experiment (Table 3) showed that direct physical contact with the backgrounds was not required for the moths to exhibit a background reflectance preference.

## DISCUSSION

The results of Experiments 1 and 2 indicate that considerable care must be taken in the design and execution of experiments which are intended as tests of background preferences in cryptic moths. Certain behaviors, particularly escape and avoidance responses, may be elicited

in some individuals and under some circumstances in an experimental apparatus, and these behaviors may interfere with background preferences. Thus, a failure to detect background preferences may result from inadequacies in an experimental test, rather than from inability of the moths themselves.

The results of Experiment 3 tend to corroborate the prevailing view that background reflectance preferences of bark-like moths are based on responses to visual stimuli. This conclusion is strengthened by field observations of released individuals of *Cosymbia pendulinaria* (and *Catocala relictata*; Sargent & Keiper, 1969). In these field tests, the erratic escape flight of certain individuals would become directed after some seconds, and this directed flight (sometimes up to 50 feet in length) usually led to an appropriate background (white birch tree). This observation, the results of Experiment 3, and numerous other experimental results (Sargent, 1968, 1969a, b) fail to support the reflectance-matching mechanism proposed by Kettlewell (1955) and Ford (1964) to explain the selection of appropriate backgrounds by bark-like moths. On the contrary, all of the evidence to date supports the view that these background selections are genetically fixed, or innate, responses.

#### ACKNOWLEDGMENTS

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NOTES ON LIFE HISTORIES AND HABITS OF SOME  
WESTERN THECLINAE

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Realizing that very little was known about life histories of several Theclinae, I made some studies of some of them. It was not difficult to get adults to oviposit in small ( $1.50 \times 3.75$  in.) "season salt" bottles which have plastic shaker tops. Eggs would be deposited on a supposed foodplant or on the sides of the bottles. Larvae were reared in metal pill boxes with fresh food supplied usually twice daily.

*Callipsyche behrii* (Edwards). This species occurs throughout most of the area from the Rocky Mountains to the Pacific Coast. It has been recorded as feeding on *Lupinus* ssp., *Astragalus* ssp., and *Lotus* ssp. (Brown, 1957; Jones, 1951; Comstock, 1927). But in central Washington the foodplant is primarily something quite different, antelope bush (*Purshia tridentata* (Pursh) DC, which is in the Rosaceae. This plant is quite common in the arid transition zone and it occurs from British Columbia and Montana to central California and New Mexico. The eggs are deposited on the stems and occasionally on the leaves of this shrub.

**Egg:** typical theclid form, diameter 0.8 mm, very light greenish, does not appear to be denticulated but is covered with small nodules. **First instar:** 2 mm, head black, body pinkish with many small dark dots and some setae. **Second instar:** 3.5–4 mm, light green with many dark green dots and small setae. **Later instars:** light green with diagonal lighter green markings laterally on each segment and a lateral light stripe. This coloring blends very well with the small leaves of the foodplant. **Pupa:** not seen.

*Incisalia fotis* (Strecker) is also found throughout the West but rather localized. It flies early in the spring and hence may be missed by some collectors. The foodplant is sedum.

**Egg:** diameter 0.6 mm, height 0.4 mm, very finely reticulated, light blue green. **First instar:** light tan with double pink stripe dorsally and single pink stripe laterally; two tubercles on each segment lateral of the pink stripes, each with two setae; head dark brown. **Mature larva:** light greenish, pronounced double pink stripe dorsally, lateral pink stripes and a ventral white stripe; dark red diagonal "hash" marks on each segment; hairs numerous, golden brown; head, light brown, sunken into the first segment. **Pupa:** length 10.5 mm, width 5.25 mm, purplish brown, dorsum lighter with many fine darker reddish lines; two rows of dark spots on each side of dorsum; dorsal line dark, many short, light brown hairs scattered over body except on wings.

*Incisalia eryphon* (Boisduval) is well distributed over the area west of the Rocky Mountains. In May 1964, I was able to get 30 or 40 eggs of

this species but have not succeeded in getting any since that time. Holland (1930) stated that the early stages were unknown. He reported that Scudder had "elaborately described" the early stages of the related *niphon*, and that the caterpillars fed on pine. Scudder (1889) did not elaborate on what part of the pine tree the larvae fed upon. The only published information I could find on *eryphon* was a brief paper by Hardy (1959). Hardy reared larvae on lodgepole pine (*Pinus contorta* Loudon) and found that they fed "in the soft and succulent base" of the needles. He described the various stages. Llewelyn Jones (1951) also reported that the larvae fed on the western white pine (*P. monticola* Douglas).

When the eggs started to hatch, I assumed the larvae would feed at the base of the needles of the yellow pine (*P. ponderosa* Lawson) that I had them on, but they died without feeding. So I tried the staminate catkins, which were ripening in May, and found that the larvae fed on them readily. They had some difficulty in boring into the catkins, so I scraped away a bit of the outer coating, after which they had no difficulty and soon had disappeared within. As the larvae grew, they were often partially outside of the catkins, but usually had the head and fore part of the body buried. One would think that, with such food, their color would be different than if they were feeding on the needles, but this was not the case. In the first instar they were honey colored and I would have expected them to remain that color in the later stages. But when they reached the third instar they became bright green. They were usually well powdered with pollen, which constituted a very rich food for them. Under laboratory conditions eggs hatched in 5 or 6 days. Because of the manner of feeding, it was not feasible to keep track of the various instars, but the total feeding time was about two weeks.

**Egg:** light green, the usual lycaenid form, diameter 1 mm, height 0.6 mm. **Newly hatched larva:** length 1.5 mm; head brown, body honey colored, a whitish line on each side of the dorsum with very short setae on each segment; anal plate small, round. **Third (?) instar:** length 11 mm; light green with a lighter green line on each side of the dorsum; many very small dark points on the abdomen from which grow short, light-brown hairs of various lengths; cervical shield greenish brown; head light brown; anal plate not evident. **Full-grown larva:** length 18 mm; ground color green; head and thoracic shield light brown; a latero-dorsal white stripe on each side of dorsum. **Pupa:** length 7.5–8 mm, width 3.5–4 mm; at first green, turning brown; dark area on each segment dorsally and a smaller round, dark spot subdorsally; a few irregular dark brown spots on wings; very fine setae scattered over body but not on wings.

*Strymon saepium* (Boisduval) occurs from the Rocky Mountains to the Pacific Coast and from southern British Columbia to southern California. In this region there are some 50 species of *Ceanothus* which is evidently the preferred foodplant. It undoubtedly feeds on more than one species,



possibly even in one area, but its preferences among the many species are not known.

Eggs were deposited on the stems and leaves, mostly on the under surface, of *Ceanothus velutinus* Douglas, and a few on *C. sanguineus* Pursh.; and on oak, in this case between the buds. Larvae would not feed on oak but fed readily on both species of *Ceanothus*, starting on the under surface. The upper surface of *C. velutinus* is somewhat sticky and feeding there is difficult. The larger larvae ate holes through the leaves and they also fed on the flower buds.

**Eggs:** the usual flattened shape, reticulated over the entire surface except the base; area about the micropyle depressed but also reticulated; light greenish; diameter 0.8 mm. **Newly hatched larva:** length 1 mm, sluglike; cream colored with many long hairs; a darker mid stripe and a lateral stripe; head light brown. **Second instar:** length 2.5 mm; light green, latero-dorsal ridges whitish; lateral ridge whitish; head black. **Third instar:** length 4-5 mm; same color and stripes; dorsal area dark green; many short spines all over body. **Fourth instar:** length 10 mm, width 3.5 mm; uniform light green except for narrow dorso-lateral whitish line. **Full-grown larva:** length 15 mm, width 5 mm; light green, two whitish dorsal stripes separated by a narrow green area; lateral stripe whitish; body covered with short golden hairs; ventral side lighter green; head small, dark brown, posterior part lighter brown. **Pupa:** length 11 mm, width 5 mm; chestnut brown with many irregular darker flecks on dorsum; head and wing covers with few hairs, many light brown ones dorsally.

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#### PRELIMINARY REPORT ON COMMUNAL RESTING OF *SMYRNA KARWINSKII* ADULTS (NYMPHALIDAE)

Since 1962 we have observed adults of *Smyrna karwinskii* (Geyer), resting in groups of ten individuals to more than 100, at all times of the day, either in small caves on a lava wall, or under concrete slabs covering alleys between some cabins on Cerro Verde. Cerro Verde, a mountain ca. 2000 m. elev., overlooks Izalco Volcano, about 50 km. WNW of San Salvador, capital of El Salvador. This phenomenon has been observed at different times of the year: March-April, August, and November-January, during both the dry and rainy season.

It had been our assumption that the groups were drinking filtration water, but this year we had a chance on 31 March to observe five groups more closely: one of about 15 individuals, one of about 20, two of about 50 and one of more than 100. All were in places protected against the wind. None of the individuals had the proboscis uncoiled, and there was no moisture present, yet the groups stayed there from the time first detected, 1015, to the time we left, 1700. From time to time individuals would fly away, and individuals would join the group. Males and females were mingled in each group, but no sexual activity was noticed.

All groups followed a certain pattern: a nucleus of about eight individuals had the heads together, so that the antennae, upraised, formed a tight fascia. Then a row of individuals formed a tight circle around this nucleus, with the antennae touching the wings of the inner group. In this way row after row were formed. Some rows did not form a complete circle, and eventually there was a line of four to five individuals breaking the regularity of the pattern, but they were encircled by the next row. All heads were pointing inward. The groups looked very much like dried moss growths.

When at the resting places the butterflies are very tame, so that specimens can be captured by hand from any place in the group, without disturbing the rest. If handled roughly the whole group will take flight, fully alert, and disperse among neighboring trees and rocks. In the surrounding woods individuals were observed while feeding on sap from wounds caused by other insects or woodpeckers high up in tree trunks.

We have not investigated yet if the individuals keep to their own groups after their occasional flights, or if they exchange locations with others; nor have we investigated if this species has acquired the behavior of forming groups just to protect themselves from the wind or predation. This behavior has not been observed in *Smyrna blomfieldia datis* Fruhstorfer, a closely related species abundant in the lowerlands.

We intend to present the full results of our investigation on this phenomenon in a future article.

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#### BIRD PREDATION ON *PAPILIO POLYXENES* F. (PAPILIONIDAE)

Birds have been shown to exert substantial predation pressure on many butterfly species (Carpenter 1940, Entomol. Mon. Mag. 76: 224-229; Rawson & Bellinger 1953, Lepid. News 7: 27; Betts 1956, Entomol. Mon. Mag. 92: 68-71; Gibb 1958, J. Anim. Ecol. 27: 375-396). However, a shortage of field observations exist in the literature dealing with bird predation on larvae and adult butterflies.

During the summer of 1971, while carrying out field studies in Ithaca, New York, on the eastern black swallowtail (*Papilio polyxenes*), several observations on bird predation were made. On 3 June, a female butterfly was taken by a bluejay (*Cyanocitta cristata* L.) as she was ovipositing on carrot (*Daucus carota* L.). In the same area on 1 July, another bluejay was seen attacking a 5th instar larva on a carrot plant. Near Homer, New York, on 31 July, a male swallowtail was taken on the wing by a catbird (*Dumetella carolinensis* L.) just after the butterfly flew from the common burdock (*Arctium minus* (Hill) Bernh.) flower upon which it had been feeding.

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## HABITAT SELECTION AND POPULATION STRUCTURE IN *PLEBEJUS SAEPIOLUS* BOISDUVAL (LYCAENIDAE)

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The importance of resource distribution has been demonstrated for the survival of both the larvae and adults of butterflies (Dethier, 1959; Gilbert, 1971; Singer, 1971). Nearly all butterfly larvae feed on the leaves and flowers of angiosperms, and most temperate zone adults depend on nectar for food. Furthermore, the relationships of butterflies and their larval food-plants may be quite specific and complex (Breedlove & Ehrlich, 1968, 1972; Downey & Fuller, 1961; Ehrlich & Raven, 1964). It is therefore reasonable to suppose that the distribution of specific plant resources may have great influence on the habitat selection of the mobile adult butterflies.

During the summer of 1971, a study was made of the structure of a population of the lycaenid butterfly *Plebejus saepiolus* Boisduval and the distribution of its resources in a subalpine meadow in Gunnison Co., Colorado. The females of this species oviposit singly on the flowers and developing fruits of the alsike clover, *Trifolium hybridum* L., and probably also on other species of *Trifolium*. It is noteworthy that *Trifolium* was found to be by far the most important adult nectar source for *P. saepiolus*.

The objectives of the study were to investigate how *P. saepiolus* distribute themselves with respect to the *Trifolium* resource and to discover how frequently individuals move within and between areas of favorable habitat. A capture-recapture technique involving a number of discrete areas was chosen in order to obtain this information.

The study site was a gently sloping meadow at 2708 m. elevation, just east of the Crested Butte, Colorado, Town Cemetery. Located in a valley, the site was not noticeably affected by any constant prevailing winds. The vegetation of the meadow was dominated by *Artemisia tridentata* Nutt. and grasses, with other plant associations occurring locally, particularly in wetter regions. The distribution of *Trifolium* was mapped over the site, and on this basis six 30 × 60 meter areas, designated "a" through "f," were selected for the study (Fig. 1). Three of these (*a*, *e*, and *f*)

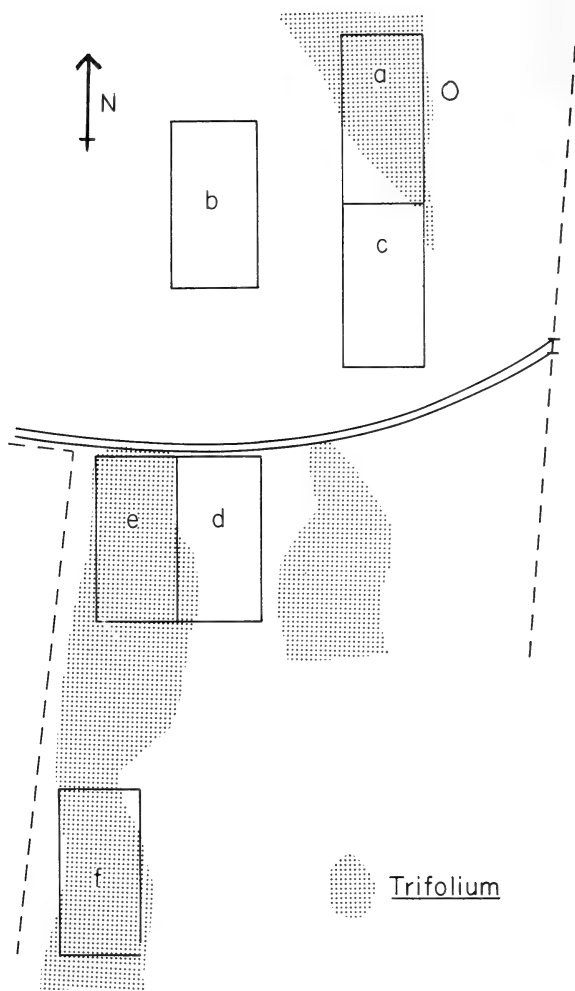


Fig. 1. *Plebejus saepiolus* study areas.

were in relatively wet regions of high *Trifolium* density, while the others (*b*, *c*, and *d*) were drier and contained little or no *Trifolium*.

On each day of the study, two people spent ten minutes in each of the six areas collecting all *P. saepiolus* found. At the end of ten minutes, all individual butterflies were sexed, marked with an individual number (except for recaptures for which the number was recorded), and released from the center of the area. Less than 1% of the insects were unable to fly when released. The marks were not conspicuous and thus were un-

TABLE 1. Total captures of *Plebejus saepiolus* in study areas (1971).

Date*	Study Areas					
	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>
6/24	10	0	1	7	17	23
6/25	15	3	0	2	22	24
6/26	12	1	1	3	22	28
6/27	12	0	0	1	22	19
6/28	12	2	2	1	28	28
6/29	10	0	0	0	19	20
6/30	15	1	0	1	22	21
7/2	15	0	0	0	26	20
7/4	10	0	0	0	20	22
Mean	12.33	.78	.44	1.67	22.00	22.78
Variance	4.75	1.19	.53	5.00	11.25	11.19
Std. Dev.	2.18	1.09	.73	2.24	3.35	3.35
Std. Dev. of Mean	.73	.36	.24	.75	1.12	1.12

\* 7/1 and 7/5 were omitted due to cloudy weather conditions which caused unusually low butterfly captures.

likely to affect either the survival of marked individuals or their probability of being captured.

### RESULTS

Before considering in detail the results of this experiment, the sex ratio of the captured butterflies should be examined. The female to male ratio was 0.19 whereas the ratio for laboratory-reared butterflies of various species is normally about 1.0 (Brussard & Ehrlich, 1970). The hypothesis that males are much more likely to be captured is supported by the recapture data in which 13% of the males marked were recaptured at least once, while only 4% of the females were recaptured. Since the two sexes are quite similar in appearance, the disparity should be due largely to behavioral differences, including greater flight activity by males. The recapture data therefore refer principally to males; females are expected to be more sedentary than the data for males would suggest. If this were true, we might expect males to be found more often in less favorable areas because of their greater mobility. The sex ratio for areas *a*, *e*, and *f* (0.20) versus that for *b*, *c*, and *d* (0.12) support this, but the data are based upon too few captures to be relied upon.

Table 1 presents information on total captures of *P. saepiolus* in the study areas. The difference between the numbers captured in the *Trifolium* areas (*a*, *e*, and *f*) and the non-*Trifolium* areas (*b*, *c*, and *d*) is highly significant ( $p < .001$ ; modified T-test). The scarcity of captures in non-*Trifolium* areas indicates that individuals are seldom found more

		Area of Recapture						
		a	b	c	d	e	f	Tot.
Area of Capture	a	13						13
	b		1					1
	c			1				1
	d					1		1
	e	2				23	2	27
	f	1				8	14	23
Tot.		16	1	1	0	32	16	(66)

Fig. 2. Matrix of capture-recapture data arranged by location.

than a few meters from *Trifolium*. This is emphasized by the low yield from area *d*, whose east and west edges follow the borders of *Trifolium* regions containing many *Plebejus saepiolus*. The data strongly suggest that habitat selection involving the oviposition plant is occurring for *P. saepiolus*.

One valuable feature of mark-release-recapture techniques is that they provide information about the movements of individuals. Fig. 2 presents in matrix form the locations of all recapture events; entries on the main diagonal represent recaptures in the same areas as the original capture and off-diagonal entries represent transfer recaptures. It is clear that most recaptures occurred in the original capture area and that most of the transfers were between areas *e* and *f* which are separated by 60 m. of favorable habitat. The ratio of transfers to same-area recaptures is 0.27 for all areas together and 0.27 for areas *e* and *f* alone. If the positions of individuals were randomized while retaining the observed number of individuals in each area, these ratios would be 2.12 and 1.00, respectively. Thus, even male *Plebejus saepiolus* do not travel freely over the 60 m. between areas *e* and *f*. An additional indication of the sedentary nature of these butterflies comes from observations of *P. saepiolus* concurrent with this study in which only 2 of the 37 individuals observed in the 30 × 60 meter region just east of area *d* were marked, while 7 of the 27 in area *e* were marked. These favorable areas are separated by 30–40 meters of drier ground not supporting *Trifolium*.

In the course of this study, male-male encounters were frequently observed. A possible effect of such encounters would be to encourage the even distribution of males over favorable habitat. The mean and variance data of Table 1 indicate that this is occurring. If the captures were totally independent events and the average population constant through time, the number of captures would follow a Poisson distribution (variance equal to the mean). Butterfly responses to weather or changes in population would increase the variance. For areas *a*, *e*, and *f*, however, the variances are about half the means. The captures are therefore not independent events, and the number of butterflies in an area is more uniform than would be expected if they did not interact.

### CONCLUSIONS

*Plebejus saepiolus*, in contrast to other species of butterflies found in subalpine Colorado (Sharp, Parks & Ehrlich, MS in prep.), shows a striking degree of correlation with the micro-distribution of its oviposition plant *Trifolium*, which itself has a patchy distribution. *P. saepiolus* appears to be quite sedentary and, as with its relative *Plebejus icarioides* Boisduval, its populations are localized. Other butterfly species in the area, notably *Erebia epipsodea* Butler (Brussard & Ehrlich, 1970) and *Colias alexandra* Edwards (Ward B. Watt, pers. comm.), range widely and have large populations. The distributions of individuals in these populations do not correlate strongly with that of their oviposition plants, and the plants themselves are widely distributed.

It seems likely that *P. saepiolus* distributions represent one strategy available to a small, weakly-flying butterfly in a seasonally unpredictable environment such as subalpine Colorado. By maintaining sedentary populations closely associated with the perennial plant which provides both larval food and nectar for the adults, *Plebejus saepiolus* can minimize uncertainties in finding a source of food.

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## FOODPLANT ECOLOGY OF THE BUTTERFLY *CHLOSYPNE LACINIA* (GEYER) (NYMPHALIDAE). I. LARVAL FOODPLANTS

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For several years I have studied field populations of *Chlosyne lacinia* (Geyer) (Nymphalidae: Melitaeini) in central and south Texas for genetic (Neck et al., 1971) and ecological genetic data. A considerable amount of information concerning foodplants of this species has been collected. Foodplant utilization information is an important base from which ecological studies may emerge. Such information is also invaluable in evaluating the significance of tested foodplant preferences of larvae and adults. Such studies have been under way by other investigators and will be available for comparison with natural population observations.

In addition to personal observations (which cover a four-year period encompassing some 20 generations), an extensive search of the literature reveals numerous, though scattered, previous reports of foodplants. Literature references to populations in central and south Texas are integrated into Table 1 with personal observations. All reports of foodplants outside the study area are discussed separately at the end of the study area foodplant discussion.

Foodplants (see Table 1) are arranged into three basic categories ac-



cording to their frequency of utilization by *C. lacinia*: I) major foodplants, II) occasional foodplants, and III) rarely utilized foodplants. Obviously these three groups are arranged in a descending order of importance. Within each group, however, foodplants are not arranged in any particular order of importance.

The first three plants on the list are by far the most important foodplants of *C. lacinia* in central and south Texas. These three plants are the most prone of all foodplants (except #7 and #10) to form large, nearly monospecific stands. Larval populations of *C. harrisii* have greater developmental success in dense fields of the foodplant, *Aster umbellatus*, as a result of smaller inter-plant distances which allow more successful larval movement to fresh plants (Dethier, 1959), rather than as a result of greater foodplant biomass which would increase the number of oviposition sites.

The last group of foodplants is almost negligible in importance and some records should be considered anomalous. These foodplants are included because some "anomalous" foodplants may be utilized at a high level under certain conditions (see foodplant #4). This latter group of plants might not fit the definition of a suitable foodplant given by Remington & Pease (1955) which is as follows: "A full test of the suitability of a plant requires that the larva be reared solely on that plant and that the adults be induced to mate and lay eggs which then hatch." In actuality, however, one plant species need not be the sole foodplant utilized in order to be considered a "full" foodplant (see Discussion).

All foodplant records are the result of adult female discrimination which resulted in oviposition of an egg mass (marked by "O" in Table 1) unless a particular record is cited as being larvae that have switched from another foodplant. Skeletonized leaf damage is typical of the gregarious early-instar larvae. Post-dispersal larvae of the fourth and fifth (final) instars chew holes through all leaf layers. Thus, it is quite simple to determine whether leaf damage typical of immature larvae is present. If none is present, the larvae are assumed to have switched from some other plant. In several instances larvae were actually observed while they were switching. This phenomenon of larval foodplant switching will be discussed in more detail elsewhere (Neck, in prep.).

All observations within the study area involve the taxon of *C. lacinia* known as *adjutrix* Scudder. Some references to populations in the western United States may refer to either *adjutrix* or *crocale* (Edwards) or mixed populations of these two phenotypes. Records from Latin America refer to *saundersi* (Doubleday), a term used to describe a form close to or including *adjutrix* (Higgins, 1960).

TABLE 1. Larval foodplants of *Chlosyne lacinia* within the study area.

Plant species	Code <sup>1</sup>	Tribe <sup>2</sup>	Range (Texas)	Habitat	Previous Records
<b>I. Major foodplants</b>					
1. <i>Helianthus annuus</i> L. Common sunflower	A-O	Heliantheae (V)	entire state, less common in east area	cleared ground and dirt piles; various soils but prefers clays	Kendall, 1959; Drummond et al., 1970
2. <i>Ximenestea encelioides</i> Cav. Cowpen daisy	A-O	Heliantheae (V)	most of state; rare in east area	disturbed sandy soils of fields and stream banks	Tinkham, 1944; Drummond et al., 1970
3. <i>Ambrosia trifida</i> L. Giant ragweed	A-O	Heliantheae (A)	entire state	seasonally wet creek beds or floodplains	Kendall, 1959
<b>II. Occasional foodplants</b>					
4. <i>Verbena virginica</i> L. Frostweed	P-O	Heliantheae (V)	eastern and central areas	shaded woodlands and thickets	Kendall, 1959
5. <i>Viguiera dentata</i> (Cav.) Spreng. Sunflower goldeneye	P-O	Heliantheae (V)	central and western areas, especially Edwards Plateau	limestone outcroppings in cracks almost bare of soil	Drummond et al., 1970
6. <i>Zexmenia hispida</i> (H.B.K.) Gray. Shrub daisy	P-O	Heliantheae (V)	Edwards Plateau, Rio Grande Plains	limestone derived soils	None
7. <i>Helianthus cucumerifolius</i> T. & G. Cucumberleaf sunflower	A-O	Heliantheae (V)	eastern and central areas	sandy soils	Kendall, 1959
<b>III. Rarely utilized foodplants</b>					
8. <i>Ambrosia artemisiifolia</i> L. Common ragweed	A-	Heliantheae (A)	all areas but Panhandle and Pecos	waste soil in full sun or partial shade	None
9. <i>Parthenium hysterophorus</i> L. False ragweed	A-O	Heliantheae (A)	all areas but east	disturbed sites; various soils	H. G. Lacey in Kendall & Kendall, 1971

TABLE 1. (Continued)

Plant species	Code <sup>1</sup>	Tribe <sup>2</sup>	Range (Texas)	Habitat	Previous Records
10. <i>Helianthus argophyllous</i> T. & G. Silverleaf sunflower	A-	Heliantheae (V)	east central and coastal plains	deep, loose sandy soils	None
11. <i>Xanthium strumarium</i> L. Cocklebur	A-O	Heliantheae (A)	entire state	moist disturbed sites	None
12. <i>Simsia caloa</i> (E. & G.) Gray. Bushsunflower	P-	Heliantheae (V)	south, central and western areas	dry soils	Drummond et al., 1970
13. <i>Calypocarpus vidalis</i> Less. Prostrate lawnflower	P-O	Heliantheae	south and central areas	heavy soils	None
14. <i>Silphium</i> sp. Rosinweed	P-O	Heliantheae	central sector	limestone knolls and prairies	R. O. Kendall in Drummond et al., 1970
15. <i>Gaillardia pulchella</i> Foug. Firewheel	A-?	Heleniae	all areas but east	abandoned pastures, fallow fields of vari- ous soils	R. O. Kendall, pers. comm.
16. <i>Heterotheca latifolia</i> Buck. Camphorweed	A-	Astereae	all areas	sandy soils	None

<sup>1</sup> A = annual, P = perennial; O = oviposition recorded under field conditions.<sup>2</sup> (V) = subtribe Verbesinae; (A) = subtribe Ambrosinae.

### Larval Foodplants Within Study Area

The botanical nomenclature of Gould (1969) was followed. All localities, unless otherwise noted, are in central and south Texas. Obviously some plants not on this list may serve as foodplants, but, due to the time spent observing *C. lacinia*, all major and occasional foodplants utilized in this area are believed to be known. Various sources (Heiser, 1947; Shinnars, 1958; Lynch, 1968; Gould, 1969; Correll & Johnston, 1970) were utilized to obtain the information on geographical range (within Texas) and preferred habitats of the various foodplants. This information is summarized in Table 1.

*Helianthus annuus* L. serves as the major foodplant from spring (first adults are normally seen around April 1 in Austin) until August. By August the great majority of these plants have become senescent due to hot, dry summer weather. The few sunflower plants that survive through summer until September rains occur are often able to survive until early winter. Larval broods have been found on this species as late as November (1971) in central Texas in favorable sites and years. Infestations have been found on *H. annuus* in deep south Texas (Santa Ana Wildlife Refuge) as late as the last week of December (1970).

Although egg masses have been found on cultivated monocephalic varieties of *H. annuus*, larval development does not appear to be as successful as on the wild form. Populations would not likely occur in cultivated fields of this species because of insecticidal treatments used against the sunflower moth, *Homeosoma electellum* (Phycitidae) (Teetes & Randolph, 1968).

*Ximenesia encelioides* Cav. is by far the major foodplant of *C. lacinia* from August (Drummond et al., 1970) until the end of the larval feeding period in November or early December. Although this annual germinates in the spring (February), most seedlings grow rather slowly until late summer rains occur (normally in September). These plants then grow rapidly and are able to support huge larval populations.

*Ambrosia trifida* L. serves as a foodplant only when there is a nearby population of *C. lacinia* on another foodplant. *A. trifida* is often found in the moister parts of a field of *H. annuus*. I have never found a pure, isolated stand of *A. trifida* to be infested with *C. lacinia*. Possibly adult females are not particularly attracted to this plant unless they have already been partially stimulated by one of the other two plants listed previously.

Although I have always found limited numbers of larvae on *A. trifida*, Kendall (1959) reported thousands of larvae in Medina Co. on a mixed stand of *H. annuus* and *A. trifida*. He also located another large popula-

tion which was feeding solely on *A. trifida* in Kendall Co. This exception may have been the result of 1957 being a particularly good year for *C. lacinia* (Kendall, 1959). The large populations that year were probably the result of a wet year following the longest Texas drought (1950–56) on record.

Until 1971 the sole record for *Verbesina virginica* L., which is a central Texas foodplant for *Chlosyne nycteis*, was Kendall's (1959) report of a single larva. In autumn 1971 I located three different infestations on this species including one large larval population. Possible reasons for utilization of this plant by *C. lacinia* in 1971 will be discussed elsewhere (Neck, in prep.).

*Xanthium strumarium* L. was not recorded as a foodplant for *C. lacinia*, despite continual checking, until autumn 1971. W. H. Calvert (pers. comm.) has reported difficulty in rearing *C. lacinia* larvae on this species (i.e., near complete arrest of development). *Gaillardia pulchella* Foug. was reported (R. O. Kendall, pers. comm.) as a foodplant in the autumn of 1970 during a severe drought when other foodplants may not have been suitable. Some foodplant records (species #'s 8, 10, 12 & 16) consist solely of instances where larvae have switched foodplant species. One of the aforementioned larval switch foodplants, *Helianthus argophyllous* T. & G. (#10), is known as a foodplant only in the artificial situation of a transplant garden at a field laboratory. No records, as a result of either oviposition or larval switching, are known under natural conditions, despite examination of numerous large stands of this species.

### Larval Foodplants Outside Study Area

Cockerell (Edwards, 1893) reported larvae on what "appears to be the common *H. annuus*" near Las Cruces, New Mexico. Later Cockerell (1900) reported them to be very common on *H. annuus* in the Mesilla Valley, New Mexico. He also found them on *Helianthus ciliaris* while a few larvae were found on *Xanthium canadense* and *Palafoxia hookeriana*. In southern California, larvae have been commonly found on *H. annuus* but a few have been found on *Viguiera deltoidea* var. *parishii* (Thorne, 1962). Comstock (1927) reports the foodplant merely as "sunflower." In Arizona it feeds on *H. annuus* and *Xanthium saccharatum* (Gorodenski, 1969). *H. annuus* is by far the most important foodplant in Arizona. Generally, *Xanthium* is utilized only in association with the former species, although one large population has been reported on the latter plant (S. A. Gorodenski, pers. comm.). According to Love & Dansereau (1959), the two taxa of *Xanthium* mentioned above are taxonomic entities of the highly variable species, *X. strumarium* (foodplant #11).

The three above states, in addition to Texas, encompass the entire range of *C. lacinia* in the United States except for occasional strays as far north as Kansas and Nebraska (Klots, 1951). Its range extends southward to Argentina (Bauer, 1951) where it feeds on a composite which Koehler (1927) believed to be a *Helianthus*. L. E. Gilbert (pers. comm.) has observed larvae on *Eupatorium* sp. in Trinidad and *Baltimora* sp. in Guanacaste Province near Canas in Costa Rica.

### Ovipositional Mistakes

Ovipositional mistakes by adult females of various lepidoptera have been previously reported (Remington, 1952; Dethier, 1959a). At times mistakes are on exotic toxic species which have native palatable congeners (Straatmen, 1962; Kendall, 1964). Only one mistake has been observed for *C. lacinia*. A normal-sized egg mass was found on a leaf of *Solanum pseudocapsicum* (Solanaceae) growing in the transplant garden of the Brackenridge Field Laboratory in the summer of 1971 (A. Hartgerink, pers. comm.). Unfortunately the egg mass was not discovered until the leaf had been kept in a refrigerator for several days, thus preventing the eggs from hatching. Normally utilized foodplants (*H. annuus*, *A. trifida* and *Z. hispida*) were present nearby in the same garden. Although observing such mistakes is largely a matter of chance, one would not expect a species laying large egg masses, e.g. *C. lacinia*, to make as many mistakes as a species which lays smaller masses or single eggs as the selective disadvantage would be much greater. Dethier (1959b) recorded no such errors for *C. harrisii*.

### Larval Foodplant Taxonomy

The above larval foodplants, all members of the family Compositae, belong to the tribe Heliantheae (Correll & Johnston, 1970) except *Gaillardia* and *Palafoxia* (both Heleniae), *Heterotheca* (Astereae) and *Eupatorium* (Eupatorieae). Cronquist (1955) independently derived these last two tribes from the Heliantheae, considered to be the most primitive tribe of the Compositae. He acknowledges, however, the possibility that the Eupatorieae may be related to the Heliantheae through primitive members of the Senecioneae.

He puts the tribe Heleniae into the Heliantheae claiming that the former tribe is a catch-all group for several groups which independently evolved from the basic Heliantheae stock. The phylogenetic arrangement described above would indicate a tight taxonomic relationship among the various foodplants of *C. lacinia*. It should be mentioned, however, that Cronquist derived all but one of the tribes of the Compositae from the primitive tribe Heliantheae.

Of the fourteen foodplants which belong to the Heliantheae, all but two belong to the subtribes Ambrosiinae (*Ambrosia*, *Xanthium*, and *Parthenium*) and Verbesiinae (*Helianthus*, *Viguiera*, *Simsia*, *Zexmenia*, *Ximenesia* and *Verbesina*). Quite far removed from these two groups, and from each other, are *Silphium* and *Calyptocarpus* (B. L. Turner, pers. comm.).

The genus *Viguiera* (see foodplant #5) is very closely related to *Helianthus* (Heiser, 1969) with generic distinctions breaking down in a few species. Blake (1918) believed that *Helianthus* evolved from the ancestral stock of *Viguiera*, an idea which has received recent support from Heiser (1957). Also noteworthy is the fact that some authorities (Correll & Johnston, 1970) place *Ximenesia* (see foodplant #2) within the genus *Verbesina* (see foodplant #4).

The three species of *Helianthus* utilized as foodplants by *C. lacinia* in central Texas are all members of the section *Annu* of *Helianthus* (Heiser, 1969). *H. argophyllous* is considered to be extremely closely related to *H. annuus* (Heiser, 1951). The only other species of this genus which is commonly encountered in central Texas is *H. maximiliani*, a perennial which is not known to be a foodplant. It belongs to the section *Divaricati* of *Helianthus*.

#### DISCUSSION

It appears that although *C. lacinia* feeds on a relatively large number of plant species, little taxonomic diversity is involved. *C. lacinia* may, therefore, be considered oligophagous, i.e., feeding on only a few species of many present throughout its geographical range.

Actually, since there has never been a definition of just how many foodplants are a "few," application of this term is somewhat the result of personal discretion. Dethier (1947) argued that the terms monophagous, oligophagous and polyphagous should be based on the number of chemicals which are perceived as attractants. Using this criterion, none of the above terms could be applied to *C. lacinia* until the chemistry of the foodplant-butterfly relationship has been analyzed. *C. lacinia* might be considered monophagous if all of the above foodplants were perceived via one chemical or a "group of closely related chemicals confused as one" (Dethier, 1947). Thorsteinson (1960) has presented a more diversified model involving differential relative importances of stimulatory and inhibitory phytochemicals. Plants related to foodplants, but not utilized by *C. lacinia*, might be distinguished by repellent or inhibitory factors (chemical or physical) not present in foodplants. For the purposes of this discussion, however, *C. lacinia* will be designated as oligophagous.

Previously we saw that *C. lacinia* is oligophagous as a species, i.e., it occurs on a number of foodplants over its geographic range. A single larval population of *C. lacinia* is most often found infesting several foodplants unless only one is available. This may be due to variance in adult ovipositional behavior or foodplant switching by larvae. Thus, one can say that *C. lacinia* may be oligophagous as a population and also as an individual. A single colony usually feeds on more than one plant and the same may be true for an individual larva.

This situation in *C. lacinia* may be contrasted with examples, from the literature, of other butterflies. *Plebejus icarioides* (Lycaenidae) can be found on numerous species of *Lupinus* (Leguminosae) although an individual population feeds on only one species, even if several species of *Lupinus* are available (Downey & Fuller, 1961). Thus, *P. icarioides* is oligophagous as a species but monophagous as a population and as an individual except in rare cases where ants, which may take the larvae into their nests for the winter, place them on a second *Lupinus* in the following spring (Downey, 1962).

Singer (1971) reports larvae of *Euphydryas editha* (which is in the same tribe as *C. lacinia*) on plants of several families, but many colonies are found on practically only one foodplant species. However, at least one population of *E. editha* regularly feeds on two different plant species (of two different plant families) in the pre-diapause and post-diapause periods (Singer, 1971). Using the same criteria utilized above, *E. editha* can be classified as being oligophagous as a species but monophagous or oligophagous as a population. One colony has been found to be regularly oligophagous as individuals. A similar situation occurs in *E. maturna* in Europe (Higgins, 1950; Higgins & Riley, 1970) and *E. phaeton* in the eastern United States (Klots, 1951). All of the species discussed in this section are oligophagous, but this oligophagy can be exhibited in various ways.

Singer (1971) reported inter-populational differences in foodplant specificity in *E. editha*. This phenomenon has not been observed in *C. lacinia*. Populations of *E. editha* are genetically isolated from one another, primarily due to the sedentary habits of the adults (Ehrlich, 1961, 1965). *C. lacinia* adults, while most commonly found in the vicinity of foodplant stands, are quite capable of flying the distance between populations. Such flights probably occur more frequently as a result of nectar source shortages which arise when adult populations become very dense. Dethier & MacArthur (1964), working with *C. harrisii*, reported an adult emigration which occurred following an increase in the larval population due to artificial stocking. This same phenomenon, i.e., density-dependent dispersal, is believed to occur in *C. lacinia*.



There is no significant spatial foodplant polymorphism in *C. lacinia* (differential foodplant preferences in spatially separated populations) as discussed for *E. editha*. Rather, *C. lacinia* exhibits a temporal foodplant polymorphism, i.e., it feeds on *H. annuus* (spring and early summer) and *X. encelioides* (late summer and fall) during two roughly separable time periods. Temporal foodplant polymorphism is known for *Papilio machaon* in desert areas where it feeds on a succession of different foodplants (Buxton, 1923). *Tephroclystis virgaureata*, a European geometrid moth, has two generations annually, the first of which reportedly feeds on *Senecio* and *Solidago* (both Compositae) while the second feeds on *Prunus* and *Crataegus* (both Rosaceae) (Klos, 1901).

It is interesting to note in Table 1 that field oviposition has been observed for all major and occasional foodplants (groups I and II). However, field oviposition is not known for some of the rarely utilized foodplants of group III. Force (1966) reported that adults of the three-lined potato beetle, *Lema trilineata*, were "more fastidious in selecting hosts for feeding and oviposition" than were larvae which attempted to feed on many unsuitable plant species. This is not really unexpected since the more mobile adults can search for other food items whereas the relatively sedentary larvae are normally forced to eat what the adult selects for its young. If the adult selected suitable foodplants, there will be no selection for larval discrimination, because the correct foodplant is always available.

#### SUMMARY

Sixteen plant species are known as foodplants of *Chlosyne lacinia* (Geyer) in central and south Texas. All of these plants are in the family Compositae and all except two are in the tribe Heliantheae. What is known of the foodplants outside the study area is reported. The type of oligophagy exhibited by *C. lacinia* is discussed in relation to oligophagy as exhibited by other butterfly species. A spatial foodplant polymorphism has not been observed, but a temporal foodplant polymorphism is reported.

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## THE COLLECTION OF BUTTERFLIES MADE BY JACK DENNIS AT BEULAH, MANITOBA

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During a period of almost 50 years A. J. Dennis, better known as Jack, resided and collected Lepidoptera at Beulah, Manitoba. He engaged in extensive exchange and sale of specimens and, as a result, his materials are distributed throughout the world. His personal collection, now in the possession of the Manitoba Museum of Man and Nature in Winnipeg, is the basis of this paper.

I have not been able to ascertain a great deal concerning Jack Dennis himself. Only three lepidopterists had direct contact with him, Jack May,

Hugh Gibbon and Shirley Brooks, all of whom are now deceased. Most of what I have been able to learn is from the G. Shirley Brooks correspondence file in the Manitoba Museum, from Don Eff of Boulder, Colorado who visited him at Beulah in 1941, and from L. P. Grey of Lincoln, Maine who had extensive correspondence with him.

Dennis started collecting Lepidoptera in the 1890s (specimens in his collection date from 1898) at Beulah. He saw action during the first world war and was disabled. After the war he returned to Beulah, where the rest of his life was a rather impoverished existence on an army pension. Of necessity, he raised vegetables and fished, but this left him with considerable time for butterfly collecting. His collecting was confined, however, to the immediate vicinity of Beulah and the nearby town of Birtle, since he had no means to travel and was apparently not physically able to do much hiking. To supplement his pension he sold specimens and also exchanged them. Among those to whom he sold specimens was Jean Gunder, who named two aberrational forms after him. Judging from the mounted specimens in his collection, his primary exchange partners were G. S. Brooks, J. A. Comstock, D. Eff, L. P. Grey, V. Harper, W. Hovanitz, H. A. Howland, J. C. Hopfinger, and J. May. After an extended illness, Jack Dennis died of cancer in Winnipeg on 12 July 1946. G. S. Brooks, at that time curator of entomology for the Manitoba Museum, purchased his collection shortly afterwards for the Museum.

The Dennis collection is contained in home-made plaques of the Riker Mount type. Specimens were carefully mounted, depinned and placed in these mounts over cotton. In spite of the fact that the collection has had virtually no care for 25 years, it is in excellent shape with no dermestid infestation. The remaining collection, in the Manitoba Museum of Man and Nature, consists of about 400 of these plaques. At one time there were considerably more. Some of the details of the original collection can be ascertained from a letter which Shirley Brooks wrote to Don Eff, 26 September 1946: "The collection proper is coming here. About half of the stuff is going to Hugh Gibbon. Well I never saw such a mess of butterflies as I found there. The collection, as you may call [sic! recall] it is all in Riker mounts, and has full data, but that consists of about a third of the total, all the remainder lacks any data, much of it beautiful stuff. Quite useless from a collectors point. Then there were about 70 boxes of papered stuff, probably 10% with data, and some of it many years old. I looked through most of it, and after selecting about 4 cigar boxes full, had a bonfire with the remainder."

The fact that Brooks selected what he wanted from the collection to take back to Winnipeg probably accounts for a number of species, known

to be taken at Beulah, being absent from the collection and the fact that there are only one or two plaques of some species but many many of others. Some of the gaps can be filled in by the fact that Dennis submitted all of his records from Beulah and Birtle to Brooks for inclusion in his (1942) list of Manitoba butterflies. All of the Beulah and Birtle records cited there are from Dennis.

Brooks had intended to organize and catalogue the Dennis collection that he took back to Winnipeg. He died in 1947 before having a chance to do this and the collection was kept in storage in the Manitoba Museum until Harvey Beck, then Keeper of Collections for the Museum, invited me to use the collection in 1968. I have ignored the non-Manitoban exchange materials in the collection, but have catalogued the remainder, mostly specimens that Jack Dennis collected himself.

Beulah and the nearby town of Birtle are located on the prairie in southwest Manitoba, just south of the Manitoba Escarpment. The lepidopterous fauna here shows predominately eastern species, but with notable incursions from the west. A few forest species stray into the area from Riding Mountain, which is part of the Manitoba Escarpment just to the north. All in all it is an interesting collecting locality and with 50 years of collecting here by Dennis, the species list should be fairly complete.

### Species Collected at Beulah and Birtle by Jack Dennis

#### HESPERIIDAE

*Amblyscirtes samoset* (Scudder). Three specimens, 14 May 1901 and 14 June 1906.  
*Amblyscirtes vialis* (Edwards). Two specimens, 16 June 1920 and 24 June 1925.  
*Euphyes vestris metacomet* (Harris). Ten specimens, 7 to 18 July, 1904 to 1943.  
*Poanes hobomok* (Harris). Nine specimens (one plaque), 6 to 18 July, 1940 and 1941. Additional plaques are undoubtedly missing.

*Polites coras* (Cramer). Twelve specimens, 1 to 24 July, 1906 to 1941.

*Polites themistocles* (Latreille). Four specimens, 11 July 1901.

*Polites mystic* (Scudder). Eight specimens, 10 to 20 July, 1921 to 1940.

[*Hesperia uncas uncas* Edwards]. Not present in the Dennis collection, however MacNeill (1964) records a male from Beulah (presumably of Dennis origin) in the Los Angeles County Museum, 22 August 1901.

*Hesperia manitoba laurentina* (Lyman). Well represented, 41 rather variable specimens, all in August, 1920 to 1940.

*Hesperia nevada* (Scudder). Seven specimens, labeled by Dennis as *H. comma colorado*, 18 to 24 June, 1940 and 1941. Also recorded from Beulah by MacNeill (1964).

*Hesperia ottoe* Edwards. One specimen, 18 August 1943, Miniota, Manitoba (possibly collected by Hugh Gibbon).

*Oarisma powesheik* (Parker). Nine specimens, 10 to 20 July, 1902 to 1920. These were labeled *O. garita* by Dennis and recorded as that species by Brooks (1942).

*Ancyloxypha numitor* (Fabricius). Four specimens, one dated 28 June 1940 noted "first ever caught," other three 4 and 10 July 1941.

*Carterocephalus palaemon mandan* (Edwards). Ten specimens, 16 to 24 June, 1901 to 1905.

*Pyrgus communis* (Grote) ssp. 18 specimens, June to August, 1912 to 1936.

*Erynnis icelus* (Scudder & Burgess). Nine specimens in three plaques, three of them labeled *E. brizo*; 14 May to 18 June, 1906 to 1938.

[*Erynnis brizo* (Boisduval & LeConte)]. Three specimens of *E. icelus* were labeled as this species by Dennis. Brooks (1942) recorded it from Beulah and Birtle on Dennis' word.

*Erynnis persius* (Scudder) ssp. One female, 18 June 1940, labeled *E. icelus*.

*Erynnis lucilius* (Scudder & Burgess). One female, 18 June 1940, labeled *E. icelus*.

This constitutes the only known record for Manitoba.

[*Erynnis juvenalis* (Fabricius) ssp.]. Brooks (1942) records this species from Beulah and Birtle on Dennis' word, but there are no specimens in the collection nor are there any labeled as such.

#### PAPILIONIDAE

× *Papilio kahli* Chermock & Chermock. I consider *Papilio kahli* to be a viable breeding population of hybrid origin. The species is well represented in the Dennis collection with over 50 specimens, mostly reared from larvae. The specimens are quite variable, ranging in appearance from that of *Papilio asterius* to *Papilio hudsonianus*, which are the presumed parental stocks. They are variously labeled *Papilio polyxenes*, *Papilio zelicaon*, *Papilio bairdii*, *Papilio nitra* and *Papilio oregonia* by Dennis, which accounts for these names on Brooks' (1942) checklist. A detailed study of the variation in this species is in preparation.

[*Papilio glaucus canadensis* Rothschild & Jordan]. Not represented in the collection, but Dennis is known to have taken it at Beulah and Birtle, as would be expected.

#### PIERIDAE

*Pieris protodice protodice* Boisduval & LeConte. A dozen specimens, mixed with the following species, May, July and August, 1920 to 1937.

*Pieris occidentalis* Reakirt ssp. Over 30 specimens, mixed with *P. protodice*, May, July and August, 1920 to 1937. Variable and very darkly marked specimens in both spring and summer broods, obviously distinct from *P. protodice* in the summer brood. These were labeled by Dennis as var. *calyce* Edwards, hence this name in Brooks' checklist.

*Pieris napi oleracea* Harris. Six specimens, 15 June to 26 July, 1904 to 1922.

*Pieris rapae rapae* (Linnaeus). Only one specimen, undated, in the collection. This species is very abundant at Beulah now, and must have been during Dennis' later years there.

*Colias eurytheme eurytheme* Boisduval. Represented by 95 specimens, 1 July to 6 September, 1924 to 1941. Of special interest are eight miniature specimens (forewing lengths 17 to 19 mm.) taken during July 1934 and labeled "caught at Beulah, Manitoba, the year of the drought."

*Colias eriphyle* Edwards or *Colias philodice* Godart ssp. Represented by 89 specimens, 24 May to 18 October, 1910 to 1944.

*Colias alexandra christina* Edwards. This is the best represented species in the Dennis collection. There are over 400 examples, including at least one plaque for nearly every year between 1902 and 1944. Male capture dates range from 12 June to 5 July, female from 16 June to 14 July. The variation in these specimens is the subject of another paper (Masters, in press).

#### DANAIDAE

[*Danaus plexippus plexippus* (Linnaeus)]. Not represented in the collection, but known to have been taken by Dennis at Beulah.

## SATYRIDAE

- [*Lethe anthedon borealis* (Clark)]. Not represented in the collection, but recorded for Beulah and Birtle by Brooks (1942). The species is abundant at Riding Mountain, a short distance to the north.
- Lethe eurydice fumosus* (Leussler). Thirty specimens, 1 to 24 July, 1903 to 1944. Series of six specimens 12 July 1903, are labeled, "Uno near Beulah, first time caught."
- Coenonympha tullia* nr. *benjamini* McDunnough. Represented by 25 specimens divided by Dennis into groups with ocelli, which he labeled *benjamini*, and groups without ocelli, which he labeled *insulana*. Dates include 16 June to 10 July, 1898 to 1936.
- Cercyonis pegala* nr. *ino* (Hall). Ten specimens in one plaque, 10 to 20 July, 1906 to 1922.
- Erebia discoidalis discoidalis* (Kirby). Four specimens, undated, possibly from Riding Mountain or some other point in Manitoba; however Beulah and Birtle were included by Brooks (1942) as localities for this species.
- Erebia epipsodea freemani* Ehrlich. One specimen, undated. Beulah is given as a locale for this species by Brooks, and in correspondence to L. P. Grey, Dennis lamented on the fact that *epipsodea* is no longer seen although it was once common before extensive agriculture.
- Oeneis uhleri varuna* (Edwards). Jean Gunder named an aberration of this species, taken by Dennis at Beulah, *O. uhleri varuna* trans. form *dennisi*. There are 25 specimens in the collection, 1 to 14 June, 1934 to 1938.
- Oeneis alberta alberta* Elwes. Represented by 29 specimens, 16 to 26 May, 1899 to 1938.

## NYMPHALIDAE

- Vanessa atalanta rubria* (Fruhstorfer). Represented in the collection by one plaque of ten specimens, 28 July to 28 August, 1908 to 1912.
- [*Cynthia virginiensis* Drury]. Not represented in the collection, but listed for Beulah and Birtle by Brooks (1942).
- [*Cynthia cardui* (Linnaeus)]. Not represented in the collection, but assumed to have been taken at Beulah by Dennis.
- [*Precis coenia coenia* (Huebner)]. Listed by Brooks (1942) for Birtle, however not represented in the collection.
- Nymphalis j-album j-album* (Boisduval & LeConte). Nine specimens, 24 July to 4 August, 1900 to 1912.
- Nymphalis milberti milberti* (Godart). Five specimens, 24 July to 1 September, 1910 to 1926.
- [*Nymphalis antiopa antiopa* (Linnaeus)]. Not represented in the collection, but known to have been taken by Dennis.
- Polygonia interrogationis* (Fabricius). Six specimens in the collection, all 24 June 1896.
- Polygonia comma* (Harris). Two specimens in the collection, undated. Recorded from Beulah by Brooks (1942).
- Polygonia satyrus neomarsyas* dos Passos. This is the commonest *Polygonia* on the western Manitoba prairies; it is represented in the collection by 17 specimens, 17 May to 25 July, 1903 to 1942.
- [*Polygonia faunus* (Edwards)]. Recorded from Beulah and Birtle by Brooks (1942), but not represented in the collection. This species is fairly abundant at Riding Mountain.
- [*Polygonia zephyrus* (Edwards)]. The record from Beulah that Dennis gave to Brooks for his Manitoba list (1942) for this species, turns out to be erroneous. The specimen is a rather darkly marked *P. progne*.

*Polygonia progne* (Cramer). Nine specimens, 9 to 24 June, 21 July and 10 September, 1936 to 1941.

*Phyciodes tharos* (Drury) ssp. There are 30 specimens of *Phyciodes* in the collection, all labeled *Phyciodes tharos pascoensis* by Dennis, but only a very few of them are actually *tharos*; most are *P. campestris*. I suspect that *tharos* is at least as common, if not more so, than *campestris* at Beulah but that Dennis primarily mounted *campestris* because they are slightly larger.

*Phyciodes campestris camillus* Edwards. See comments on preceding species; 2 to 20 July, 1906 to 1938. This is the first published record for *P. campestris* in Manitoba, although I have found it moderately abundant in recent years at the Lake Audy Prairie area in Riding Mountain National Park.

*Chlosyne gorgone carlota* (Reakirt). Represented by 19 mounted and many, many papered specimens, this is evidently one of the most abundant species at Beulah; 8 to 20 June, 1936 to 1944. The Beulah population seems to be distinct from more typical *carlota*. The ground color of the wings is more "pinkish" and the black markings on the dorsal surfaces are reduced in much the same manner as in *C. nycteis reversa*. The southwest Manitoba population of this species could be given subspecific recognition.

*Chlosyne nycteis reversa* (Chermock & Chermock). One specimen only, a female, 28 June 1900, included in a plaque with six specimens from Sylvania, Ohio with 1939 and 1940 dates. The inference is that the species is very rare here and the one specimen more than likely the only one caught.

[*Chlosyne harrisii* (Scudder) and *Chlosyne hanhami* (Fletcher)]. Neither of these are represented in the collection, but Dennis apparently captured both at Beulah or Birtle as recorded by Brooks (1942). In a letter to G. S. Brooks, dated 9 May 1943, Dennis states that he takes *C. harrisii* in green spots near springs and *C. hanhami* in more open terrain. The two are sympatric over much of southern Manitoba and remain distinct; *harrisii* is smaller and prefers wooded habitats while the much larger *hanhami* is found on the prairies.

*Boloria selene* (Denis & Schiffermüller) ssp. One very lightly marked male, 28 July 1944 at Birtle; presumably the only example of this species taken by Dennis.

*Boloria bellona* (Fabricius) ssp. Only one plaque of nine specimens in the collection, 18 June to 14 July, 1900 to 1940, would indicate a rarity at Beulah. Hugh Gibbon took these in numbers at Miniota during the 40's and 50's.

*Speyeria callippe calgariana* (McDunnough). Four specimens; female 10 July 1900, male 16 July 1902, male 14 July 1909, and female 20 July 1909.

*Speyeria edwardsii* (Reakirt). Four specimens; male and female 17 July 1898, male 14 July 1928, and female 24 July 1936.

*Speyeria atlantis dennisi* dos Passos & Grey. This was originally described by Jean Gunder as "*Argynnis lais* tr. f. *dennisi*." This name, as proposed by Gunder, is not available; transitional form was his term for designating aberrant specimens. The name *dennisi* was elevated to the subspecies rank by dos Passos & Grey (1947); this is its first availability. The species is better known as *Argynnis* or *Speyeria lais* Edwards in the literature, but unfortunately this name is not available, the *Argynnis lais* of Scudder having priority. The species is common at Beulah in late summer.

*Speyeria mormonia eurynome* (Edwards). Two specimens at Beulah, a female 23 July 1937, and a male 28 July 1938. There is another Manitoba specimen in the Dennis collection, 25 July 1935, from Riding Mountain.

*Speyeria cybele pseudocarpenteri* (Chermock & Chermock). Represented by 18 specimens, 24 July to 18 August, 1920 to 1934. These are relatively small for *cybele*. *Speyeria aphrodite manitoba* (Chermock & Chermock) would be expected to occur here with *cybele*, but it is not represented in the collection, nor is it recorded from Beulah by Brooks (1942).

*Euptoieta claudia claudia* (Cramer). Six specimens, 10 to 26 July, 1920 to 1938.



## LYCAENIDAE

- Satyrium liparops fletcheri* (Michener & dos Passos). One plaque with three specimens from Birtle, 15-16 July 1940, plus four more specimens taken by Hugh Gibbon at Miniota, 18 July 1942.
- Satyrium acadica watrini* (Dufrane). Two specimens, only one dated, 12 July 1941. [*Harkenclenus titus* (Fabricius) ssp.]. Not represented in the collection, however recorded from both Beulah and Birtle by Brooks (1942).
- Lycaena thoe* Guérin-Ménéville. Eight specimens, only six dated, 10 to 17 July, 1906 and 1907.
- Lycaena xanthoides dione* Scudder. Nine specimens, 16 to 20 July, 1904 to 1940.
- Lycaena helloides* (Boisduval). Nineteen examples, 8 to 24 July, 1900 to 1930.
- Lycaeides melissa melissa* (Edwards). Four specimens, all females, 1 to 16 July, 1924 to 1938.
- Plebejus saepiolus* (Boisduval) ssp. Eleven examples, 8 to 20 July, 1900 to 1914.
- Agriades rustica* manuscript ssp. Brown. Represented by 24 specimens, 10 to 20 June, 1900 to 1936.
- Everes comyntas comyntas* (Godart). There is one plaque of five specimens, undated, that were labeled as *comyntas* by Dennis. Of these only one male is actually *comyntas*, the others are *amyntula*. Southern Manitoba is part of a very limited area where these two species are sympatric.
- Everes amyntula albrighti* Clench. Two males and two females, undated; see comments under *E. comyntas*.
- Glaucopsyche lygdamus afra* Edwards. Eight specimens, only six of them dated, 14 June to 17 July, 1907 to 1910.
- Celastrina argiolus argentata* Fletcher. Twelve specimens, all from the spring brood, 20 to 25 May, 1906 to 1920.

## ACKNOWLEDGMENTS

I would like to acknowledge the assistance of J. Richard Heitzman of Independence, Missouri who made the determinations of HesperIIDae for me; and H. Harvey Beck and Robert W. Nero, both formerly of the Manitoba Museum of Man and Nature, for making the arrangements that allowed me to make this intensive study of the Dennis collection.

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# A REVIEW OF THE *AMBLYSCHIRTES* WITH THE DESCRIPTION OF A NEW SPECIES FROM MEXICO (HESPERIIDAE)

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## Genus *Amblyscirtes* Scudder 1872

Generotype *Hesperia vialis* Edwards

*Amblyscirtes* Scudder, Rept. Peabody Acad. 1871, 75 (54), 1972.

*Stomyles* Id. op. cit. 76 (55). Generotype *Pyrgus textor* Hubner.

*Mastor* Godman, Biol. Cent.-Am., Rhop. II. 567, 1900. Generotype *Mastor anubis* Godman.

*Epiphyes* Dyar, Jn. N. Y. Entomol. Soc. XIII, 132, 1905. Generotype *Pamphila carolina* Skinner.

Antennae short, approximately  $\frac{1}{2}$  costa; shaft checkered, white under the club; club stout,  $\frac{1}{4}$  shaft; apiculus obtuse from thickest part of club, short equal width of club; nudum  $\frac{4}{6}$ . Palpi cylindrical, upturned; second segment with shaggy vestiture, third segment slender, smooth, and vertical, almost as long as second in most species. Mid and hind tibia spined. Males with either brands or a stigma on the upper side of the primaries. Primaries in most species similar in both sexes. Costa flattened; apex rounded-rectangular; outer margin strongly rounded except toward anal angle; cell about two-fifths as long as wing. Secondaries rounded, in most of the species longer through cell than in most of the related genera. Genitalia rather peculiar in that the saccus and aedoeagus, in most species, are very long, extending nearly to the thorax.

There are 31 species in the genus *Amblyscirtes*, and for the present I do not recognize any subspecies. Biological and distributional data as well as basic morphological characteristics indicate to me that several previously recorded subspecies actually represent valid species and are thus treated in this review. The members of this genus are placed into four groups by Evans and I follow his arrangement. The first group is the Exoteria Group which is characterized by the presence of more or less ochreous scaling on the upper surface of the wings and by the presence of at least grey scaling on the lower surface of the secondaries. A cell spot or spots may or may not be present. The second group is the Aesculapius Group which is characterized by being greyish-brown to black, with a well marked single or double cell spot on either the upper or lower surface of the primaries, and discal spots or grey scaling on the lower surface of the secondaries. The third group is the Vialis Group which is characterized by being greyish-brown to black, with no cell spot on the primaries, and by having discal spots or greyish scaling on the lower surface of the secondaries. The fourth group is the Phylace Group which is character-

<sup>1</sup>I would like to express my appreciation to the American Philosophical Society for a research grant which made it possible for me to conduct this work on the *Amblyscirtes*.

ized by having no markings on the lower surface of the secondaries. There is considerable diversity superficially among members of this genus, however with the exception of *simius* Edwards there is a remarkable similarity in the male genitalia of all of the species. Often worn specimens are very difficult to identify even after an examination of the genitalia due to this great consistency in basic form.

The genus *Amblyscirtes* reaches its greatest development in the southwestern part of the United States with Texas being the metropolis as 13 species have been recorded from that state. There have been two species recorded from Canada, 22 from the United States, 19 from Mexico, and one from Cuba. Records from Central and South America are lacking indicating that this is strictly a North American genus.

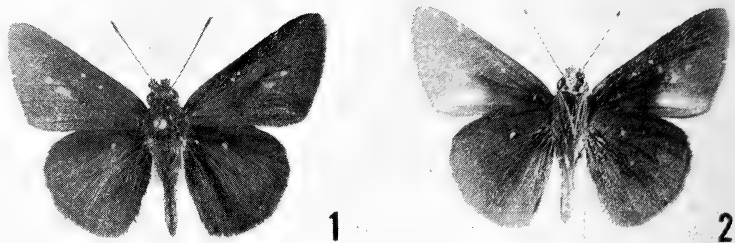
#### Key to the Species

- 1a. Under surface of secondaries marked with at least grey scaling; usually apical spots present ..... 2
- 1b. Under surface of secondaries unmarked; apical spots absent ..... 27
- 2a. Upper surface with more or less ochreous scaling ..... 3
- 2b. Upper surface without ochreous scaling, greyish-brown or brownish-black .. 12
- 3a. Primaries with a pale cell spot; 15–20 mm wide ..... 4
- 3b. Primaries without a cell spot; 13–14 mm wide ..... 9
- 4a. Under surface of primaries cell brown; cilia checkered; a distinct broken stigma present ..... 5
- 4b. Under surface of primaries cell orange; cilia checkered or unchecked; an indistinct broken stigma or brands present ..... 8
- 5a. Under surface of primaries have a suffused white discal area in space 1b ... 6
- 5b. Under surface of primaries lacks suffused white discal area in space 1b ... 7
- 6a. Cilia white, faintly checkered; primaries 15–18 mm wide; distinct white discal and cell spots on lower surface of secondaries ..... *folia*
- 6b. Cilia sordid white, unchecked; primaries 20 mm wide; indistinct yellowish spots in spaces 2 and 3; lower surface of secondaries uniform chocolate brown with faint indication of yellowish discal spots ..... *raphaeli*
- 6c. Cilia brown; primaries 16 mm wide; white discal spots present on lower surface of secondaries ..... *insulac-pinorum*
- 7a. Cilia distinctly checkered brown and white; distinct white spots present on primaries and lower surface of secondaries; primaries 15–18 mm wide ..... *exoteria*
- 7b. Cilia indistinctly checkered light brown and white; all spots on both wings indistinct or absent; primaries 18–20 mm wide ..... *immaculatus*
- 8a. Cilia white, unchecked; apex on lower surface of primaries and of lower surface of secondaries grey, overscaling the usual white markings; indistinct broken stigma present; primaries 13 mm wide ..... *simius*
- 8b. Cilia checkered light and dark brown; grey overscaling on apex and lower surface of secondaries sparse; distinct brand present against cubitus and between origins of veins 3 and 2 and under vein 2; primaries 13 mm wide ..... *cassus*
- 9a. Maculation on primaries and lower surface of secondaries usually prominent, especially the apical spots ..... 10
- 9b. Maculation on primaries and lower surface of secondaries reduced and in some cases nearly absent ..... 11

- 10a. Maculation on primaries and lower surface of secondaries prominent, with an ochreous spot or spots in space 1a and sometimes 1b on the upper surface of primaries; maculation on lower surface of secondaries usually clear white; brands between origins of veins 3 and 2 and under vein 2 inconspicuous ..... *aenus*
- 10b. Maculation on primaries and lower surface of secondaries somewhat reduced with no spot in space 1a or 1b; maculation on lower surface of secondaries never clear white, usually dusky; brands prominent on upper surface of primaries ..... *erna*
- 10c. Maculation on primaries reduced, prominent on lower surface of secondaries, often clear white; generally ground color darker than in above two species; brands prominent on upper surface of primaries ..... *linda*
- 11a. Lower surface grey; heavy grey overscaling on lower surface of secondaries; cilia sordid white; coloration on upper surface pale brown; brands on primaries conspicuous ..... *oslari*
- 11b. Lower surface dark brown; grey overscaling very sparse on lower surface of secondaries; cilia dusky; maculation ochreous on upper surface of primaries; brands inconspicuous ..... *fluonia*
- 12a. A distinct single or double cell spot on upper or lower surface of primaries .. 13
- 12b. No cell spot on upper or lower surface of primaries ..... 20
- 13a. Brands present on upper surface of primaries ..... 14
- 13b. Grey stigma present on upper surface of primaries; primaries 11 mm wide; cilia usually plain brown; maculation on primaries faint or absent; lower surface of secondaries dark brown, overscaling sparse, with distinct tiny white discal and cell spots present ..... *elissa*
- 14a. On the upper or lower surface of the primaries there is a distinct white spot in space 1b ..... 15
- 14b. On the upper or lower surface of the primaries there is an obsolete olive spot in space 1b, or it may be absent; cilia checkered; maculation on primaries above olive scaled; brands under cubitus and vein 2 inconspicuous; on the lower surface of the secondaries there is a heavy grey overscaling causing the white markings to be blurred; primaries 13 mm wide ..... *samoset*
- 15a. Cilia checkered ..... 16
- 15b. Cilia not checkered ..... 19
- 16a. On the lower surface of the secondaries there is distinct grey scaling and small white spots; veins are concolorous with rest of wing ..... 17
- 16b. No distinct spots on upper surface of secondaries; on the lower surface of the secondaries grey scaling absent; veins more or less white on the lower surface of the secondaries, with the discal spots united into a band; primaries 14 mm wide; brands inconspicuous ..... *aesculapius*
- 17a. There is a small white cell spot and discal spots on the upper surface of the secondaries; on the upper surface of the primaries there are spots in spaces 4 and 5; on lower surface of secondaries there is an extra spot in 1c under origin of vein 2 ..... 18
- 17b. No spots on the upper surface of secondaries; on the lower surface of the secondaries there is grey overscaling with more or less distinct white spots present; there may or may not be an ochreous spot in space 1b on the primaries; brands inconspicuous; primaries 13 mm wide ..... *texanae*
- 18a. Small, primaries 13 mm wide, pale in coloration; upper and lower cell spots large and usually fused on primaries; brands narrow under cubitus and vein 2; on the under surface of the primaries the costa and apex, as well as the entire under surface of the secondaries, densely overscaled with violet-grey scales ..... *prenda*
- 18b. Larger, primaries 14 mm wide, darker in coloration; upper and lower cell spots small, seldom fused; narrow brands under cubitus and vein 2 in-

distinct; violet-grey overscaling greatly reduced on lower surface of wings ..

- ..... *tolteca*
- 19a. Primaries 13 mm wide; brands distinct under cubitus and vein 2; on the lower surface of the primaries the costa and apex is heavily overscaled with dull yellow as is the entire lower surface of the secondaries; indistinct rusty brown maculation on the lower surface of the secondaries ..... *carolina*
- 19b. Primaries 13 mm wide; brands distinct under cubitus and vein 2; dull yellow overscaling on lower surface of wings sparse or absent, with the ground color rusty brown; maculation on lower surface of secondaries dull yellow and distinct ..... *reversa*
- 20a. Cilia white, not checkered; primaries 13 mm wide; brands short and fairly broad under cubitus and vein 2; maculation on upper surface of primaries conspicuous, extending into space 1b; there are discal spots on the upper surface of the secondaries; on lower surface of secondaries there is heavy greenish overscaling with the usual whitish discal spots present ..... *neruus*
- 20b. Cilia more or less checkered; no spot in space 1b on the primaries; no spots present on the upper surface of the secondaries ..... 21
- 21a. Lower surface of secondaries abnormal, variegated with large white, dark brown and greenish patches; primaries 12 mm wide; brands long and narrow under cubitus and vein 2; apical spots prominent on primaries, other maculation reduced ..... *nysa*
- 21b. Lower surface of secondaries normal with grey scaling and white spots usually present or at least indicated ..... 22
- 22a. On the lower surface of the secondaries the grey overscaling is heavy and the white discal spots are conspicuous and dark edged; primaries 12 mm wide; brands short and fairly broad under cubitus and vein 2 ..... *eos*
- 22b. On lower surface of secondaries the grey overscaling is sparse and the white discal spots are poorly defined or absent ..... 23
- 23a. Apical spots on primaries abnormal, increasing in size from space 6 to space 8, an additional spot in space 9, and white streaks on the costa at the ends of spaces 8-11; primaries 13 mm wide; very short brand present under vein 2; spots in spaces 2 and 3 on primaries indistinct or absent; on lower surface of secondaries grey overscaling indistinct, with only the slightest indication of discal spots ..... *vialis*
- 23b. Apical spots on primaries normal, dots in spaces 6, 7, and 8, and no streaks on the costa ..... 24
- 24a. Usually prominent spots in spaces 2 and 3 on the primaries ..... 25
- 24b. Usually no spots in spaces 2 and 3 on the primaries ..... 26
- 25a. Spot in space 2 rounded on the primaries; upper cell spot on primaries often present; primaries 12-14 mm wide, not produced; brands well developed, against cubitus and a long streak under vein 2; on lower surface of secondaries grey overscaling fairly heavy, with the discal spots sordid white to dusky ..... *celia*
- 25b. Spot in space 2 V-shaped on the primaries; no upper cell spot on primaries present; primaries 12-14 mm wide, produced; brands well developed under cubitus and vein 2; on lower surface of the secondaries the grey overscaling is sparse, with the discal spots grey and often rather indistinct ..... *belli*
- 26a. Primaries 11 mm wide; brands reduced to a tiny dash above vein 2 against the cubitus; apical spots present on primaries; grey overscaling fairly sparse on lower surface of secondaries, with greyish, indistinct discal spots present ..... *alternata*
- 26b. Primaries 12-14 mm wide; long brand present under vein 2; no maculation present on the upper surface of primaries; on lower surface of primaries indistinct apical spots are present; on lower surface of secondaries there



Figs. 1, 2. *Amblyscirtes raphaeli* n. sp. Holotype male. Candelaria Loxicha, Oaxaca, Mexico, 7 August 1969 (E. C. Welling; A. M. N. H.)

- may be present some scattered white scales and the slightest indication of of discal spots ..... *florus*
- 27a. Palpi below orange or yellowish white ..... 28
- 27b. Palpi below black with ochreous hairs intermixed; cilia on primaries yellowish-white, on secondaries dark brown; narrow stigma broken at vein 2 and extending just below that vein ..... *anubis*
- 28a. Cilia sordid white in the males, sordid white to grey in the females; palpi below orange in the males, yellowish-white in the females; males have a broad and short band covering vein 2 near its origin on the primaries .... *phylace*
- 28b. Cilia orange in both sexes; palpi below orange in both sexes; males have a narrow broken grey stigma from origin of vein 3 to vein 1 ..... *fimbriata*

### Exoteria Group

#### 1. *Amblyscirtes folia* Godman 1900

**Synonym:** *tutolia* Dyar 1913: Mexico.

**Type locality:** Mexico.

**Distribution:** MEXICO. Colima: Salada, VI-67. Guerrero: Acahuizotla, IX-60; Chilpancingo; Mexcala, VII-5-56; Tierra Colorado, IX-61. Jalisco: Ajijic, IX, X-65, 66; Lake Chapala, VI.

This species is readily recognized by the well marked discal and apical spots on the primaries, the whitish streak in space 1b on the lower surface of the primaries, and the clear white discal and cell spots on the lower surface of the secondaries. It occurs in semi-tropical and tropical areas of western Mexico.

#### 2. *Amblyscirtes raphaeli* Freeman, new species

**MALE (Upper Side).** Primaries dark brown, with an indistinct apical spot in space 6. A distinct yellowish spot in space 2, and another similar spot in space 3 situated outward from the spot in space 2. A fairly broad, slightly broken, black stigma extending from space 1 to the end of the cell. Fringes yellowish-white, not checkered. Secondaries dark brown, immaculate. Fringes yellowish-white, not checkered.

**MALE (Under Side).** Primaries, brown, with the discal spots distinct. Apical spot in space 6 present but very indistinct. A broad suffused yellowish area in space 1b

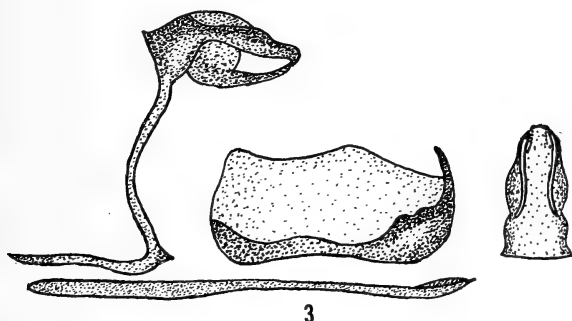


Fig. 3. Male genitalia. *Amblyscirtes raphaeli* n. sp. Paratype. Candelaria Loxicha, Oaxaca, Mexico, 21 July 1969 (E. C. Welling; H. A. F.).

extending from the middle of the space to the outer margin. Secondaries dark chocolate brown, with practically no overscaling present. The slightest indication of three yellowish discal dots, otherwise immaculate.

Thorax dark brown, both above and below. Abdomen dark brown above, somewhat lighter below. Head brown. Palpi brown with yellowish intermixed scales present. Antennae, shaft brown above, below indistinctly ringed with narrow yellow lines; club, basal half greyish above, yellow below, terminal end and apiculus black above, lighter below with the apiculus being tan.

**Wing Measurements:** Primaries: base to apex, 20 mm; apex to outer angle, 14 mm; outer angle to base, 15 mm. Secondaries: base to end of vein 3, 15 mm; center of costa to anal angle, 14 mm. Total expanse: 39 mm.

**Type Material:** Holotype. Male, Candelaria Loxicha, Oaxaca, Mexico, 7 August 1969, obtained from Eduardo C. Welling, will be placed in the American Museum of Natural History, New York. There are nine male paratypes, all obtained from Eduardo C. Welling, from the same location, 21 July 1969, 6 August 1971, 11 August 1971, 14 August 1971, 20 August 1971, and 25 August 1971, which will remain for the present in the H. A. Freeman collection.

This new species is the largest known *Amblyscirtes*. Previously *immaculatus* Freeman represented the one with the greatest expanse of wings as the primaries from the base to the apex were 18 mm wide, while in *raphaeli* that distance is 20 mm. *Raphaeli* slightly resembles *immaculatus*, however there are four basic differences: (1) *raphaeli* has discal spots in spaces 2 and 3 on the primaries which are absent in *immaculatus*; (2) *raphaeli* has a yellow apical spot in space 6 which is absent in *immaculatus*; (3) *raphaeli* has on the lower surface of the primaries a broad suffused yellowish area in space 1b which is absent in *immaculatus*; and (4) there are basic differences in the genitalia.

This new species is named in honor of my good friend Senor Raphael Aguirre, manager of Hotel Covadonga, south of Ciudad Valles, S. L. P., who has given me much assistance in my collecting in Mexico.

This distinctive species can be readily recognized by its large size and the chocolate coloration on the lower surface of the secondaries. Ap-

parently this is a jungle species as the known specimens were collected in such a habitat in Oaxaca.

### 3. *Amblyscirtes immaculatus* Freeman 1970

**Type locality:** Salada, Colima, Mexico.

**Distribution:** MEXICO. Colima: Salada, VI-67. Guerrero: Acahuizotla, VII-65.

This species is conspicuous by its large size and the reduction of all maculation. It flies in company with *folia* and seems to prefer semi-jungle areas as its natural habitat.

### 4. *Amblyscirtes nisulae-pinorum* Holland 1916

**Type locality:** Isles of Pines, Cuba.

**Distribution:** CUBA. Isles of Pines.

Evans considered this species to be a subspecies of *folia*, however morphological and biological characteristics indicate to me the distinctness of the two species. Data available indicate this species to be endemic to the Isles of Pines, Cuba.

### 5. *Amblyscirtes exoteria* (Herrich-Schaffer) 1869

**Synonyms:** *nanno* Edwards 1882: Arizona. *marcus* Strand 1907: "Delagoa Bay."

**Type locality:** not known.

**Distribution:** UNITED STATES. Arizona. Apache County: White Mountains, VII-4-51. Cochise County: Carr Canyon; Chiricahua Mountains, VI-28-42; Huachuca Mountains, VIII; Onion Saddle Pass, Chiricahua Mountains, VII-11-60; Paradise, VII-10-60. Graham County: Fort Grant; Mount Graham. Pima County: Madera Canyon, VII-6-10-60, VII-10-15-64; Mount Lemmon, VII-60. MEXICO. Jalisco. Veracruz: Orizaba, VI. Sonora: northern section, VI, VII.

This species can easily be separated from *folia* by the absence of the whitish streak in space 1b on the lower surface of the primaries. Personal observations and recorded data reveal that this species is usually found in semi-arid mountainous regions of Arizona and northern Mexico, and rarely in the mountains of Veracruz.

### 6. *Amblyscirtes simius* Edwards 1881

**Type locality:** Oak Creek and Pueblo, Colorado.

**Distribution:** UNITED STATES. Arizona, VI. Colorado. Oak Creek Canyon. Baca County: Regnier, VI. El Paso County: Fountain Valley School, V. Larimer County: Ft. Collins, V-18-69. Pueblo County: Pueblo, VII. Saguache County: Saguache, VIII-2-67. Nebraska. Sioux County: VII. New Mexico. Colfax County: Raton, VII-15-45. Grant County: Silver City, VIII. Texas. Armstrong County: Palo Duro Canyon, IV, V-42. Jeff Davis County: Davis Mountains, VII-30-53.

Superficially *simius* resembles other members in its group of *Amblyscirtes*, however its genitalia do not approach the basic genitalic



pattern of other members of this group. This is a species confined to more or less semi-arid mountainous terrain in the western section of the United States.

### 7. *Amblyscirtes cassus* Edwards 1883

**Type locality:** Mount Graham, Arizona.

**Distribution:** UNITED STATES. *Arizona.* Hannegan, VII-6-51. Cochise County: Chiricahua Mountains, VI-28-42, VII-1-51; Ramsey Canyon, VI-28. Pima County: Madera Canyon, VII-9-60, VII-10-64. *New Mexico.* Sandoval County: Jemez Springs, V. *Texas.* Jeff Davis County: Davis Mountains, VI-13-60. *MEXICO.* Baja California north, VI. Jalisco: Ajijic, X-7-65. Sonora, VI.

*Cassus* prefers mountainous canyons for its normal habitat, with southern Arizona being the center of distribution. Rarely is it found in northwestern Mexico. The orange cell area on the lower surface of the primaries as well as the double cell spot on the primaries makes this small species easy to recognize.

### 8. *Amblyscirtes aenus* Edwards 1878

**Type locality:** Southern Colorado.

**Distribution:** UNITED STATES. *Arizona.* Cochise County: Chiricahua Mountains, VII-10-60; Paradise, VII-10-60. Pima County: Madera Canyon, VII-6-60, VII-12-64; Mount Lemmon, VII-15-64. *Colorado.* Baca County: Regnier, VI. Boulder County: Boulder, V-VI; Boulder Canyon, VI; gulch south of Jamestown junction, V-31-54; Lefthand Canyon, VI-12-54; Mesa Trail, V-16-54; Six Mile Canyon, V-12-54; north Soda Springs, VI-8-53; Sugar Loaf Mountain, V-29-55. El Paso County: Rock Creek, V-21-32. Jefferson County: Chimney Gulch, VII; Clear Creek Canyon, V-17-29; Coal Creek, VI-14-38; Plainview, 4-6, VII. *New Mexico.* Quay County: Tucumcari, VI-1-42. Sandoval County: Jemez Springs, VI. *Texas.* Armstrong County: Palo Duro Canyon, V-9-42. Brewster County: Alpine, IV-20-62, VI-16-60; Chisos Mountains, VIII-9-61, VII-10-62. Jeff Davis County: Davis Mountains, VI-10-60; Fort Davis, VI-9-42. Palo Pinto County: Palo Pinto, III-31-50. *MEXICO.* Durango: Rio Nazas Valley near El Rodeo, VIII-18-22-68 (Peter Hubbell), AMNH, (new record for Mexico).

This is a rather variable species as to the extent of the white discal spots on the lower surface of the secondaries. Some specimens have these spots clear white and very prominent, while others may have them dusky and almost obsolete. It occurs rather commonly over the southwestern and midwestern parts of the United States, usually in the mountains.

### 9. *Amblyscirtes erna* Freeman 1943

**Type locality:** Palo Duro Canyon, Texas.

**Distribution:** UNITED STATES. *Kansas.* Barber County: V-5-45. *Oklahoma.* Cimarron County: Black Mesa, V-3-47, V-21-49. Comanche County: Cache, VI-27-42. Woods County: Freedom, IV-21-46. *Texas.* Armstrong County: Palo Duro Canyon, IV-30-44, V-10-42, VII-28-42. Brewster County: Alpine, VI-10-42. Gray

County: Lake McClellan, V-14-44. Roberts County: Miami, VIII-6-42. MEXICO. Tamaulipas: Ciudad Victoria, VIII-15-16-62.

*Erna* was placed by Evans as a synonym of *fluonia* Godman based on a specimen that I sent him plus one in his collection labelled Texas, ex coll Fruhstorfer. This was done without any knowledge of the biology of the two species and insufficient morphological data—actually the two are very distinct. Both *fluonia* and *erna* fly in the mountains just west of Ciudad Victoria, Tamaulipas, Mexico, with *erna* occurring at slightly lower elevation than *fluonia* normally; however, they have been collected together in several locations. *Erna* prefers rocky canyon areas, whereas *fluonia* is usually located in shaded spots on the mountain sides. There are differences in the genitalia; however the easiest point of distinction between the two species is found on the lower surface of the secondaries, as *fluonia* has rather heavy overscaling giving the wing a mottled appearance, while *erna* has very light overscaling giving a uniform appearance to the wing. Usually the discal spots are better defined on this surface of the wing in *erna* as rarely are they discernable in *fluonia*.

#### 10. *Amblyscirtes linda* Freeman 1943

**Type locality:** Hope Hill Farm, Faulkner County, Arkansas.

**Distribution:** UNITED STATES. *Arkansas*. Carroll County: Eureka Springs, V-3-64. Faulkner County: Hope Hill Farm, VI, VII; Pinnacle Springs, VII-2-42. *Missouri*. Barry County: Cassville, V, VI. *Oklahoma*. Comanche County: Cache, VII-20-42, VIII-16-42. Washington County: Blue Springs, IV-67.

This species was treated as a subspecies of *aenus* by Evans from which it is very distinct both morphologically and biologically. Morphologically the maculation is very different and the brands on the primaries are more prominent in *linda* than they are in *aenus*. Biologically *linda* is a woods species, whereas *aenus* is confined to more semi-arid, mountainous terrain. In its western range *linda* overlaps *erna* in the Wichita Mountain section of Oklahoma.

#### 11. *Amblyscirtes oslari* Skinner 1899

**Type locality:** Chimney Gulch, Colorado.

**Distribution:** UNITED STATES. *Arizona*. Pima County: Tucson, VII-6-60. *Colorado*. Archuleta County: Arboles, VI-25-55; Juanita, V-13-36. Boulder County: Boulder, VI; Boulder Canyon, VI-13-53; Four Mile Canyon, VI-7-53; gulch south of Jamestown Junction, V-31-54; Lefthand Canyon, VI-10-53; Six Mile Canyon, V-29-54. El Paso County: Williams Canyon, VII-7-31. Jefferson County: Chimney Gulch, V-28-18; Coal Creek; Golden, VI. Park County: Mill Gulch, V. *Kansas*. Barber County: IV-28-46, V-27-45. *New Mexico*. Sandoval County: Jemez Springs, VI. *North Dakota*. Slope County: Bad Lands, VI-11-61. *Oklahoma*. Woods County: Freedom, IV-21-46, VI-9-45. *Texas*. Armstrong County: Palo Duro Canyon, IV, V, 62. Baylor County: IV-30-70. Brewster County: Alpine, VI-5-42. Carson County: White Deer, V-20-43. Jeff Davis County: Fort Davis, VI-3-40.

This species has a rather wide range over the midwestern section of the United States. It is readily recognized by the reduced maculation on the primaries and on the lower surface of the secondaries. It seems to prefer semi-arid, rather mountainous terrain for its natural habitat.

## 12. *Amblyscirtes fluonia* Godman 1900

**Type locality:** Mexico.

**Distribution:** MEXICO. Federal District: Zoquiapan, VIII-6-56. Guerrero: Amula; Chilpancingo; Xucumanatlan. Hidalgo: Jacala, VIII-1-63. Jalisco: Ajijic, VIII, IX, 65; Lake Chapala. Michoacan: San Juan Pura, VI-27-47. Morelos: Cuernavaca, VII-28-61. Oaxaca: Oaxaca, VI-22-64. Puebla: Acatlan, VIII-20-64. Tamaulipas: Ciudad Victoria, VIII-62.

*Fluonia* is readily separated from *erna* by its darker coloration and by the heavy, mottled, overscaling on the lower surface of the secondaries. *Fluonia* usually flies in areas of fairly high elevation. In the mountains west of Ciudad Victoria, Tamaulipas, *erna* usually occurs at an elevation of 2850 feet, whereas *fluonia* occurs from 3600 to 7000 feet. *Fluonia* is fairly common in the state of Jalisco as well as in the general vicinity of Oaxaca, Oaxaca.

## Aesculapinus Group

## 13. *Amblyscirtes elissa* Godman 1900

**Type locality:** Guerrero, Mexico.

**Distribution:** MEXICO. Chiapas: Acapetahua, III-60. Guerrero: Acahuizotla, VII-60; Dos Arroyos; Iguala, VIII-51; Rincon; Tierra Colorada. Morelos: Jantepéc, VI-42.

This small, dark greyish-brown, species can be readily recognized by the reduced maculation and grey stigma on the primaries, and by the lower surface of the secondaries being dark brown with tiny distinct white discal and cell spots present. Apparently *elissa* is a rather rare species confined mainly to Guerrero and Chiapas.

## 14. *Amblyscirtes samoset* (Scudder) 1863

**Synonyms:** *hegon* Scudder 1863: White Mts., New Hampshire. *nemoris* Edwards 1864: Portsmouth, Ohio. *argina* Plotz 1884: "Brisbane."

**Type locality:** Massachusetts.

**Distribution:** CANADA. Manitoba: Stone Mountain, VI. New Brunswick. Quebec. UNITED STATES. Arkansas. Faulkner County: Hope Hill Farm, IV-13-68. Connecticut. Avon, VI. Georgia. Fulton County: Indian Trail, Atlanta, IV-14-16-55. Iowa. Grinnell. Maine. Mt. Desert Island, VI-5-31. Cumberland County: Portland, VI-38. Kennebec County: Augusta, VI, VII. Penobscot County: Eastfield, VI-15-37; Passadumkeag Bog, VI-16-40. Piscataquis County: Baxter Park, Mt. Katahdin, VII-2-40. Massachusetts. Boston, VI. Minnesota. Aitkin, Carlton, Roseau, Lake of the Woods Counties, VI-67. New Jersey. Sussex County: Ogdensburg, VI. New York.

Tompkins County: Oneonta, VIII-2-68. *Ohio*. Hamilton County: Cincinnati, V-15-38.

This is a rather common and widespread species over the eastern part of the United States and southern Canada. It can be recognized by the general characteristics given in the key to the various species. The only specimens that I have collected came from Arkansas in a wooded area during the spring of the year.

### 15. *Amblyscirtes texanae* Bell 1927

**Type locality:** Sunny Glen Ranch, Alpine, Texas.

**Distribution:** UNITED STATES. *New Mexico*. Quay County: Tucumcari, VIII-25-41. *Texas*. Armstrong County: Palo Duro Canyon, IV-26-43. Brewster County: Alpine, V-31-42, VI-13-60; VI-2-42, VIII-7-61. Jeff Davis County: Davis Mountains, VI-13-60; Fort Davis, VI-11-49.

This species is common in the Alpine and Davis Mountain sections of southwestern Texas. It is most often found in rocky ravines where it flies rapidly for short intervals then abruptly comes to rest on the rocks where it will remain for a short time then repeat the same procedure again.

### 16. *Amblyscirtes tolteca* Scudder 1872

**Type locality:** Tehuantepec, Oaxaca, Mexico.

**Distribution:** MEXICO. Guerrero: Acapulco, VII-36; Acuitlapan, VII-21-56; Iguala, VII; Rio Balsas, VI. Jalisco: Guadalajara, VII. Oaxaca: Candelaria Loxicha, VII-14-71; Tehuantepec, VIII-64. San Luis Potosi: Hotel Covadonga, 6 miles south Ciudad Valles, VI, VII, VIII; Tamazunchale, VII-63, VIII-24-67. Tamaulipas: Ciudad Mante, VI-9-41; Ciudad Victoria, VIII-16-62; El Solto, VIII-19-62, VIII-24-67. Veracruz: Jalapa, VI-64; Orizaba, VIII-67; Presidio, VIII. Yucatan: Valladolid.

*Tolteca* is primarily a jungle species, however I have found specimens in brush environments in the state of Tamaulipas. In areas of dense vegetation most specimens will be found feeding on flowers that are usually shaded from the sun or else resting in the jungle shade.

### 17. *Amblyscirtes prenda* Evans 1955

**Type locality:** Tucson, Arizona.

**Distribution:** UNITED STATES. *Arizona*. Pima County: Tucson, VI-22-55. MEXICO. Chiapas: Comapapa, VII-24-69. Guerrero: Taxco, VII-1-36. Nayarit: Tepic, IX-64. Sonora: 7 miles southeast of Alamos, VIII-67; Guaymas.

Evans considered *prenda* to be a subspecies of *tolteca*, however from available information *prenda* appears to be a distinct species. Morphologically *prenda* differs from *tolteca* in the maculation, and by being smaller in size and lighter in coloration. There are slight differences in the genitalia. Biologically the two are very different as *prenda* occurs in arid

or semi-arid terrain very often flying in the heat of the day, whereas *tolteca* is a jungle species nearly always found in shaded areas.

### 18. *Amblyscirtes aesculapius* (Fabricius) 1793

**Synonyms:** *textor* Geyer 1831: U. S. A. *oneko* Scudder 1863: Connecticut. *wakulla* Edwards 1869; Apalachicola, Florida.

**Type locality:** North America.

**Distribution:** UNITED STATES. *Alabama.* Mobile County: Mobile. *Florida.* Orange County: Rock Springs, III-30-38. *Georgia.* Chatham County: Savannah, V-24-51. *Kentucky.* Jefferson County: VIII-9-69. *Mississippi.* Hinds County: Brownsville, IX-2-57; Clinton, VIII-25-56. *Tennessee.* Davidson County: Nashville, VIII. *Texas.* Harris County: Sam Houston National Forest, VI-6-71. Harrison County: Caddo Lake, VIII. *Virginia.* Nansemond County: Dismal Swamps, near Suffolk, VI-8-41; Jerico Ditch, near Suffolk, IX-7-59; Magnolia, VII-17-59; Suffolk, VI-21-40.

This very distinctive species is basically confined to the southern and southeastern part of the United States. It prefers wooded areas for its normal habitat.

### 19. *Amblyscirtes carolina* Skinner 1892

**Type locality:** South of Hamlet, Richmond County, North Carolina.

**Distribution:** UNITED STATES. *North Carolina.* Gaston County: Gastonia, VIII-27-38. Richmond County: Hamlet, VIII. *Virginia.* Nansemond County: Great Dismal Swamps, VII; Suffolk, VII-1-40.

*Carolina* seems to be confined to the North Carolina-Virginia area. This species is readily recognized by the heavy overscaling of dull yellow on the costa and apex of the lower surface of the primaries and the entire lower surface of the secondaries. The lower surface of the secondaries is indistinct rusty brown. This species is usually associated with swampy areas.

### 20. *Amblyscirtes reversa* Jones 1926

**Type locality:** Suffolk, Virginia.

**Distribution:** UNITED STATES. *Georgia.* Fulton County: Atlanta, V-12-56; Harris Trails, Atlanta, VII-17-55. Rabun County: V-4-55. *North Carolina.* Leland, VI-28-44. *Virginia.* Nansemond County: Suffolk, V-28-45, VI-9-41, VII-20-59, VII-9-44.

*Reversa* has long been considered to be a synonym of *carolina* or at most a form. I believe that actually it is a distinct species due to morphological differences such as the absence or obsolete dull yellow overscaling on the lower surface of the wings, and the differences on the lower surface of the secondaries where the ground color is rusty brown and the maculation is dull yellow and distinct. There are also slight differences in the genitalia. This species ranges further south than *carolina* being found in Georgia as well as in the same areas as *carolina*. I have both species from Suffolk, Virginia.

## Vialis Group

21. *Amblyscirtes nereus* Edwards 1876

**Type locality:** South Apache, Arizona.

**Distribution:** UNITED STATES. *Arizona.* Graham County: Mount Graham, VI. South Apache. *New Mexico.* Texas. Brewster County: Alpine, III-27-61, VI-2-42, VII-19-51. Jeff Davis County: Davis Mountains, VI-30-60, VII-27-53, VII-30-63, VIII-19-51; Fort Davis, VI-9-11-49. *MEXICO.* Chihuahua. Sonora.

This is a distinctive species from the southwestern part of the United States and Chihuahua, Mexico. It is found in arid or semi-arid terrain and often in rocky ravines. It will often rest on greyish soil where its coloration blends well with its surroundings.

22. *Amblyscirtes nysa* Edwards 1877

**Synonym:** *similis* Strecker 1878: New Braunfels, Texas.

**Type locality:** Texas.

**Distribution:** UNITED STATES. *Arizona.* Pima County: Baboquivari Mountains, IX-50; Tucson, VII-10-60. *Arkansas.* Carroll County: Beaver, VI. *Kansas.* Douglas County: V-X. Greenwood County: Eureka, IX-1-40. Harper County: X. Montgomery County: V-X. Scott County: X. Shawnee County: VII. Summer County: Caldwell, X-2-41. *New Mexico.* Eddy County: Carlsbad Caverns, VI-10-58. Quay County: Tucumcari, VII-11-42. *Texas.* Armstrong County: Palo Duro Canyon, IV-26-43, V-16-42, IX-2-43. Bexar County: San Antonio, VI, VII, VIII, X. Brewster County: Alpine, VI-5-42; Sunny Glen Ranch, Alpine, VI-2-42. Cameron County: Brownsville, VI-6-71. Carson County: White Deer, IV-VI. Childress County: Childress, VIII-7-41. Comal County: New Braunfels, VI, VIII. Dallas County: Dallas, IV-3-38; Garland, VIII-7-71; Lancaster, VIII-1-41; Vickery, VI-16-40. Gray County: Lake McClellan, V-14-44. Hidalgo County: Pharr, V-30-47. Jeff Davis County: Fort Davis, VII-10-49. Terrell County: Sanderson, VII-12-49. Uvalde County: Uvalde, V-31-42. Val Verde County: Del Rio, VI-5-49. *MEXICO.* Northern Mesa. Nuevo Leon: Monterrey, VI-10-12-35.

This small species is common over a large section of the midwest and southwestern sections of the United States and on down to the state of Nuevo Leon in Mexico. It is readily recognized by the variegated lower surface of the secondaries. *Nysa* is a familiar visitor to city flower gardens as well as rocky ravines in arid parts of the southwest.

23. *Amblyscirtes eos* (Edwards) 1871

**Synonyms:** *comus* Edwards 1876: Texas. *nilus* Edwards 1878: Texas. *quinque-macula* Skinner 1911: Las Cruces, New Mexico.

**Type locality:** Dallas, Texas.

**Distribution:** UNITED STATES. *Arizona.* Cochise County: Portal, VI-20-63. Santa Cruz County: Nogales, VII-11-64. *New Mexico.* Dona Ana County: Las Cruces, VI. Eddy County: Carlsbad, VII-9-49. *Texas.* Armstrong County: Palo Duro Canyon, IV-17-43, V-1-43. Brewster County: Alpine, VIII-19-57; Marathon, VI-3-40. Carson County: White Deer, VIII-23-41. Culberson County: Guadalupe Pass, VII-9-49. Dallas County: Dallas, VIII-7-50; Garland, IV-10-49; Lancaster, III-21-54. Jeff

Davis County: Davis Mountains, VII-27-53; Fort Davis, VI-11-49. Kerr County: Kerrville, VI-4-49. Palo Pinto County: Palo Pinto, VIII-13-55. Potter County: 15 miles north of Amarillo, VIII-10-41. Val Verde County: Del Rio, VII-12-49. MEXICO. Northern Sonora. Northern Mesa.

*Eos* is associated with arid or semi-arid regions of the southwest. It can readily be recognized by the clear white, distinctive maculation on the lower surface of the secondaries.

#### 24. *Amblyscirtes vialis* (Edwards) 1862

**Synonym:** *asella* Herrich-Schaffer 1869: locality not known.

**Type locality:** Rock Island, Illinois.

**Distribution:** CANADA. British Colombia, Corfield, Vancouver, VI. Manitoba, Miniota, VI-16-37. Ontario. UNITED STATES. *Arkansas.* Cleburne County: Quitman, VII-12-40. Faulkner County: Enders, VII-12-43; Hope Hill Farm, IV-20-45, IV-26-33, VI-12-40, VI-26-43, VI-27-44, VII-2-42; Pinnacle Springs, VII-1-43. Pulaski County: North Little Rock, VI-2-32. *California.* Sierra County: w. of Downieville, VI-17-67. Trinity County: Yosemite, VI. *Colorado.* Boulder County: Boulder Canyon, VI-19-41; Eldora, VI-24-33; Spring Gulch, VII-1-55. El Paso County: Bear Creek, V-31-32; Broadmoor, V-30-49; North Cheyenne Canyon, V-31-32; Rock Creek, VI-11-30, VII; William's Canyon, VII-7-31. Grand County: Muddy Pass, VII-5-41. Jefferson County: Clear Creek Canyon, V-17. La Plata County: Junction Creek, VI-17-37; La Plata Mountains, VII-6-38. Larimer County: Rocky Mountain National Park, VII-5-35. Park County: Tappan Creek 6 mi. NW of Lake George, V-30-49. *Florida.* *Georgia.* Fulton County: Indian Creek Road, Atlanta, VI-6-57. *Idaho.* Priest Lake. *Illinois.* Mercer County: Perryton Township, V, VI, VII, 67. Scott County: Rock Island. *Kansas.* Douglas County: Lawrence, IV-6-67. Franklin County: VII-5-54. Greenwood County: Eureka, VIII-28-40. Pottawatomie County: VI. Scott County: VI. *Maine.* Penobscot County: Enfield, VI-11-39, VI-4-40; Passadumkeag, VI-1-36, VI-12-39. Caratumb, VI-2-41. *Minnesota.* Nicollet County: VIII-12-67. *Mississippi.* Tishomingo County: Tish State Park, IV-20-57. *Missouri.* Greene County: Willard, VII-13-38. *New Hampshire.* Randolph. Franconia, White Mountains. *New Jersey.* Woodbury; Elizabeth. *New Mexico.* Sandoval County: Jemez Springs, V, VI. *New York.* Rensselaer County: Berlin, V-30-41. Tompkins County: VI-40. *North Carolina.* Cranberry, VII. *Ohio.* *Oklahoma.* McIntosh County: Checotah, VII-25-41. *Pennsylvania.* *Texas.* Dallas County: Cedar Hill, IV-5-42, IV-7-44; Dallas, V-13-37; Garland, VIII-20-71; Lancaster, V-16-41; Vickery, VI-16-40. *Vermont.* Mt. Equinox. *Virginia.* *Wisconsin.*

This is the most common and widespread species in the genus. In most areas where it is abundant it is usually associated with wooded areas. I have failed to locate specimens in arid or semi-arid habitats. *Vialis* is readily recognized by the distinct apical spots and absence or reduction of other spots on the primaries and by the uniform coloration on the lower surface of the secondaries.

#### 25. *Amblyscirtes celia* (Skinner) 1895

**Type locality:** New Braunfels, Texas.

**Distribution:** UNITED STATES. *Texas.* Bexar County: San Antonio, VI-5-56, VII-30-42. Cameron County: Brownsville, VI-8-40, VI-5-71. Comal County: New Braunfels, VI-30-40, VII-2-60. Dallas County: Lancaster, IX-28-40. Hays County:

San Marcos, VI-12-40. Hidalgo County: Mission, VII-15-63, VII-31-45; Pharr, constant. Nueces County: Corpus Christi, VI. Val Verde County: Del Rio, VI-5-49, VII-12-49. MEXICO. Nuevo Leon: Monterrey, VI-19-35. San Luis Potosi: 6 miles south Ciudad Valles (Hotel Covadonga), VI-15-71. Tamaulipas: Ciudad Mante, VI-23-64; Ciudad Victoria, VI-23-64, VII-26-66, VIII-16-62; San Francisco, VIII-64.

This species is usually found in wooded areas, very often in the shade. *Celia* has a rather restricted range as it occurs from the Lancaster, Dallas County, Texas area into northcentral Mexico. I have found *celia* rather abundantly in the vicinity of Monterrey, N. L., Mexico.

## 26. *Amblyscirtes belli* Freeman 1941

**Type locality:** Vickery, Dallas County, Texas.

**Distribution:** UNITED STATES. *Arkansas*. Faulkner County: Enders, VII-12-43; Hope Hill Farm, VI-24-44, VII-24-44, VIII-1-44; Pinnacle Springs, VII-27-43. *Pulaski County*: Little Rock, VII-21-41, VII-21-43; North Little Rock, VII-5-41. *Georgia*. Madras, VII-23-34. *Fulton County*: Riverside Drive, Atlanta, V-21-57. *Illinois*. Southern Illinois, VII. *Missouri*. Greene County: Willard, VII-25-29. *North Carolina*. Meck County Road, VII-26-70. *Oklahoma*. McIntosh County: Checotah, VII-25-41. *Texas*. Dallas County: Dallas, IV-12-38, IV-22-40, V-4-40, VII-20-42; Garland, IV-28-68; Lancaster, VIII-16-40; Vickery, VIII-5-40, VIII-16-40.

*Belli* was recorded as a subspecies of *celia* by Evans, however there are a number of reasons why the two are separate. Biologically their habits are different as *belli* prefers open fields and the edges of woods, whereas *celia* prefers the woods. I have collected both species in the same general area at Lancaster, Texas, where their range overlaps. Morphologically they are easily separated as the males of *belli* have the spot in space 2 on the primaries V-shaped, while *celia* has this spot oval. On the lower surface of the secondaries *celia* usually has the discal spots lighter and more distinct than in *belli* where this area is usually rather dark and hoary. *Celia* often has a cell spot on the primaries which is completely lacking in *belli*. There are slight differences in the genitalia, however genitalic determinations in the genus *Amblyscirtes* are practically impossible with most species due to the fact that the basic pattern is very similar.

## 27. *Amblyscirtes alternata* (Grote & Robinson) 1867

**Synonym:** *meridionalis* Dyar 1905: Georgia.

**Type locality:** Atlantic District, Georgia.

**Distribution:** UNITED STATES. *Alabama*. Whistler, IX. *Houston County*: Cowarts. *Florida*. Orange County: Orlando, III-17-42. *Georgia*. Scriven County: IV-9-46, V-18-46. *North Carolina*. Leland, VI-17-45. *Texas*. Smith County: Tyler, IX-5-49; Tyler State Park, III-24-59, IV-5-59.

This small species is readily recognized by the general maculation which is characterized by the three apical spots being needle-like points,



and the indistinct discal spots. On the lower surface of the secondaries the wings are uniform dark brownish-black evenly overscaled with small grey scales. Specimens that I have collected were found in the general vicinity of piny woods.

28. *Amblyscirtes florus* (Godman) 1900

**Synonym:** *mate* Dyar 1923: Guerrero, Mexico.

**Type locality:** Sierra Madre de Tepic, Nayarit, Mexico.

**Distribution:** MEXICO. Colima: Comala, VIII-4-67. Guerrero. Jalisco: Ajijic, IX-3-66; La Cumbre de Autlan, VII, VIII-67. Morelos: Jantepec, VI-49. Nayarit: Sierra Madre de Tepic. San Luis Potosi: 6 miles south of Ciudad Valles (Hotel Covadonga), VI-10-66, VIII-6-67. Tamaulipas: Ciudad Victoria, VIII-16-62; 15 miles south of Llera, VII-27-66. Veracruz: Catemaco, VIII-10-67.

This jungle species is characterized by its uniform brownish-black coloration, devoid of any maculation on the upper side. On the lower surface of the wings the primaries have very indistinct discal and apical spots and the secondaries have indistinct discal spots present. I have found *florus* to be rather abundant at times at Hotel Covadonga just south of Ciudad Valles, particularly in the jungle along the Rio Valles.

### Phylace Group

29. *Amblyscirtes anubis* (Godman) 1900

**Type locality:** Mexico.

**Distribution:** MEXICO. Guerrero: Omilteme; Sierra Madre del Sur. Hidalgo: Apulco, IV-52. Veracruz: Jalapa; Orizaba.

This rather rare species can be recognized by the orange-yellow fringe of the primaries and the concolorous fringe of the secondaries. The palpi are grey in both sexes. There is a narrow broken stigma on the primaries of the males.

30. *Amblyscirtes phylace* (Edwards) 1878

**Type locality:** Southern Colorado.

**Distribution:** UNITED STATES. Arizona. Cochise County: VIII-99. Colorado. El Paso County: Rocky Creek, VII-7-37. Jefferson County: Chimney Gulch; Clear Creek Canyon, V-26-21; Lookout Mountain, VI-25-39. Park County: Mill Gulch, VI-10-21. Teller County: Rosemont, VI-29-32. New Mexico. Dona Ana County: Rincon, VI. Sandoval County: Jemez Springs, VI-9-14, VI-26-14. Texas. Jeff Davis County: McDonald Observatory, VI-9-49, VII-11-49, VIII-5-62, VIII-10-60. MEXICO. Morelos. Puebla: La Malinche.

This species can be identified by the sordid white fringe of both wings. In the males the palpi are orange, while in the females they are yellowish-white. The males have a broad, short brand central vein 2 near its origin on the primaries. *Phylace* is usually found in semi-arid mountains.

31. *Amblyscirtes fimbriata* (Plotz) 1882

**Synonym:** *bellus* Edwards 1884: Southern Arizona.

**Type locality:** Mexico.

**Distribution:** UNITED STATES. *Arizona.* Cochise County: Chiricahua Mountains, VI-28-36, VI-26-36; Onion Saddle Pass, VII-12-60; Pinery Canyon, VII-11-60; Portal, VII-10-60; Ramsey Canyon, VI-28-36; Rustlers Park, VI-20-63. *New Mexico.* Sandoval County: Jemez Springs. *MEXICO.* Las Vigas. Durango: Milpas. Nuevo Leon: Chipinque Mesa, Monterrey, VIII-13-67. *Sonora.* Valle de Mexico. Veracruz: Jalapa.

This species can be recognized easily by the presence of an orange fringe on both wings in both sexes, also by the palpi being orange in both sexes. The males have a narrow, broken, grey stigma from the origin of vein 3 to vein 1. *Fimbriata* usually occurs in wooded mountainous terrain.

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A REVISION OF THE *COLIAS ALEXANDRA* COMPLEX  
(PIERIDAE) AIDED BY ULTRAVIOLET REFLECTANCE  
PHOTOGRAPHY WITH DESIGNATION OF A NEW SUBSPECIES<sup>1</sup>

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This paper presents a study of the distribution and taxonomy of the *Colias alexandra* complex. The role of ultraviolet photography as an aid to taxonomic studies is discussed and is employed in assigning *C. alexandra* populations to various color groups. Visible light characters (pigmentation and facies) are combined with uv reflectance patterns to arrive at the taxonomic conclusions presented. One concludes from this study that some populations of *alexandra* can be assigned to specific subspecies, while others are best listed as clinal or intergrade forms. Based upon uv photography, *C. harfordii* and *C. barbara* are assigned to the *alexandra* complex. As a consequence of recent work by Brown (1973), a new subspecies of *alexandra* is proposed.

Butterfly color patterns are produced by both pigmentation and optical effects. The brilliant prismatic colors associated with many tropical species are produced by visible light interference with the structures of certain wing scales. As shown by Mazokhin-Porshnyakov (1954) and Nekrutenko (1964), certain Coliadinae reflect ultraviolet light from particular wing areas such that interference patterns are produced.

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Ghiradella, Eisner, Hinton, and Silberglied (pers. comm. and in review) have determined that these uv reflection patterns are structural and are analogous to the white-light-produced brilliant iridescent blues in the genus *Morpho*. Silberglied (pers. comm.) has shown that interference of uv light rays in the layered lamellae which comprise the ribs of special wing scales is responsible for the "luminous" patches shown in the accompanying figures. Close spacing of the ribs is indicative of strong uv reflection.

Kolyer & Reimschuessel (1969) reported some scanning electron microscope studies of *Colias eurytheme* Boisduval but did not interpret the structure of the scales. The lamellae are shown in Figs. 2c & d of their paper. A simple method for making uv photographs has been described by Ferris (1972b).

Ultraviolet reflectance photography can be used as a taxonomic aid as suggested by Nekrutenko (1964). Some species of *Colias* are reflective; others are not. Reflection is used here in a relative sense and is applied to fresh undamaged specimens. There is always some reflection of uv light, but only certain species reflect sufficient energy to produce bright patterns. Reflection in *Colias* generally occurs from the discal areas (dorsal) of the secondaries and varies considerably for the primaries. Males of certain species are reflective, while the females of the North American species are non-reflective. Ultraviolet photography of the non-reflective species is of no taxonomic value except to separate reflective and non-reflective species in questionable cases.

*Colias alexandra* males exhibit a uv reflectance pattern which appears as a luminous patch on the secondaries and is constant in all of the color forms. The term "luminous" is used here to describe the appearance of the reflection pattern in a black-and-white photograph. The amount of reflectance from the primaries varies from insignificant in the pure yellow races to considerable in the orange races. Fig. 3 illustrates the features which separate *alexandra* from other North American *Colias*. Figs. 4-5 illustrate examples of *C. alexandra* as they appear under white light photography and uv photography. A dull background has been used purposely to eliminate spurious uv fluorescence.

Ultraviolet photography is used here to assign *alexandra* populations to various color groups. It shows that several populations which appear yellow to the human eye, exhibit uv interference patterns characteristic of the yellow-orange group. These populations are therefore placed with the yellow-orange group rather than with the "pure" yellow group. Uv photography cannot be used to make assignments at the subspecies level generally, although it does show that *C. barbara* and *C. harfordii* belong in the *alexandra* complex.

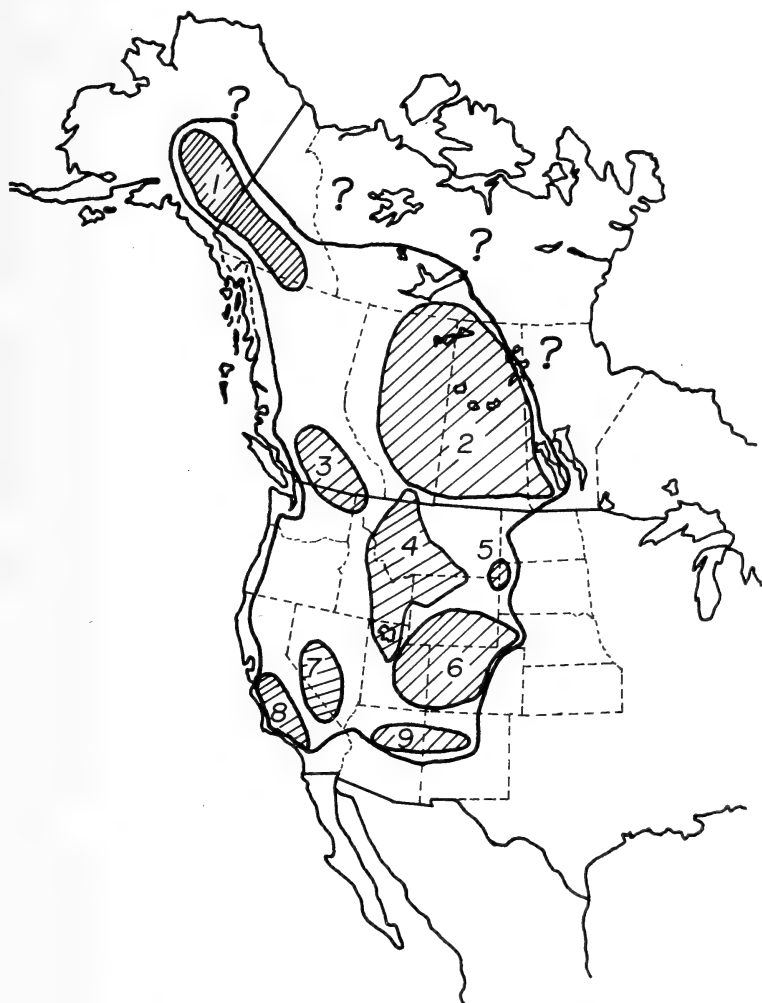


Fig. 1. Distribution of *Colias alexandra* in North America. The outer solid line encloses the known areas in which *alexandra* has been found. The northern boundary is still in doubt as indicated by (?). The shaded areas represent distinct subspecies as follows: 1, unnamed Alaska-Yukon segregate; 2, *christina*; 3, *columbiensis*; 4, *astraea*; 5, *krauthii*; 6, *alexandra*; 7, *edwardsii*; 8, *barbara* and *harfordii*; 9, Arizona-New Mexico segregate. The remaining areas within the boundary represent intergrade forms which cannot be clearly identified as any one given taxon.

### Biology

The life histories of several members of the *alexandra* group have been published and are cited in Davenport & Dethier (1937). Larval food-plants are members of the Leguminosae. There is a paucity of specific

hostplant records in the literature, but these records include: *C. alexandra*: *Astragalus*, *Thermopsis*, *Trifolium repens* (Davenport & Dethier, 1937); *Astragalus serotinus* (Opler, unpublished); *A. miser* (Shields, et al., 1969). *C. christina*: *Trifolium* (Davenport & Dethier, 1937). *C. harfordii*: *Astragalus* (Davenport & Dethier, 1937); *A. antisellii* (Locoweed) (R. C. Priestaf, 1972, pers. comm.). Davenport & Dethier list additional authors who have reported hostplant preferences for *alexandra*.

*Colias alexandra* is found in a wide variety of habitats. Generally it frequents open areas, and in forested land is found in clearings and along roads or cuts. Males may be found at puddles along dirt roads where they sometimes congregate in large numbers. Some of the subspecies are common in open sagebrush regions (Upper Sonoran Desert), while others frequent the Transition Zone (aspen-conifer association), and still others are found in meadows or clearings in the Canadian Zone. In the Far North, *alexandra* appears to prefer open clearings in the taiga (spruce-scrub biome). Pigmentation in the adults does not appear to be correlated with habitat. To some extent, correlation with latitude exists, with more orange color appearing in the north.

### Distribution and Taxa

The *C. alexandra* complex is widely distributed in western North America (Fig. 1). Three distinct color forms are recognized: yellow, yellow and orange, and orange, in addition to clinal forms in which specimens from a given geographic location vary from yellow into almost pure orange (Ferris, 1972a). Currently recognized taxa belonging to the *alexandra* complex are indicated below according to visible-light color (pigmentation).

#### YELLOW POPULATIONS—TAXA

- Colias alexandra alexandra* Edwards, 1863 [T. L. Front Range, west of Denver, Colorado].  
*Colias alexandra edwardsii* Edwards, 1870 [T. L. Virginia City, Storey Co., Nevada].  
*Colias alexandra emilia* Edwards, 1870 [T. L. Oregon]. See discussion below.

#### YELLOW-ORANGE POPULATIONS—TAXA

- Colias alexandra astraea* Edwards, 1872 [T. L. Yellowstone Lake, Wyoming].  
*Colias alexandra christina* Edwards, 1863 [T. L. Slave River Crossing, N.W.T., Canada].

#### ORANGE POPULATIONS—TAXA

- Colias alexandra krauthii* Klots, 1935 [T. L. Black Hills, 12 miles west of Custer, Custer Co., South Dakota].

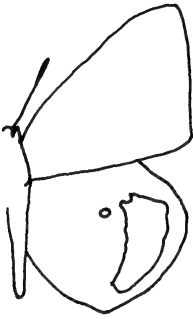
The taxon *alberta* Bowman has been omitted as it appears to describe a hybrid situation and suppression of this name has been recommended



Fig. 2. Distribution of *Colias alexandra* isolates. Open circles—yellow populations; half-open circles—yellow-orange populations; solid circles—orange populations.

(Ferris, 1972a). This and other possible *alexandra* crosses are discussed in the paper cited.

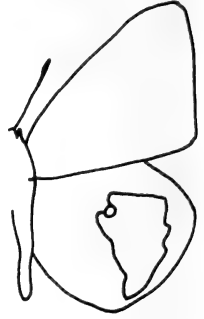
When long series of *alexandra* of a given subspecies or from a given locality are examined, one notices substantial variation in pigmentation and, in the females, maculation. Some individual males from yellow-orange races appear yellow under white light. When photographed under uv illumination, they exhibit luminous patches on the primaries which



(a)



(b)



(c)



(d)



(e)



(f)



(g)



are characteristic of the yellow-orange group. In the current study, uv photography is used to assign various races or populations to one of the three designated color groups. Race or population should not be inferred as synonymous with subspecies. The uv patterns for each group are discussed below.

There is considerable variation in uv reflectance pattern as well as in pigmentation. The former is illustrated by the accompanying figures. Only *C. a. alexandra* and *C. a. krauthii*, the poles so-to-speak, exhibit minimal variation. The angle at which uv radiation strikes the wing surfaces affects the reflection pattern (Nekrutenko, 1965). If specimens are flat-mounted and illuminated as suggested by Ferris (1972b), this problem is minimized.

In the following paragraphs, reference is made to various isolated populations. These represent clinal and intergrade forms which do not merit subspecific recognition. Localities are shown in Fig. 2.

#### YELLOW POPULATIONS—DISTRIBUTION

Arizona, California, Colorado, Nebraska, Nevada, New Mexico, Oregon (isolate), Utah, Wyoming, Montana (?).

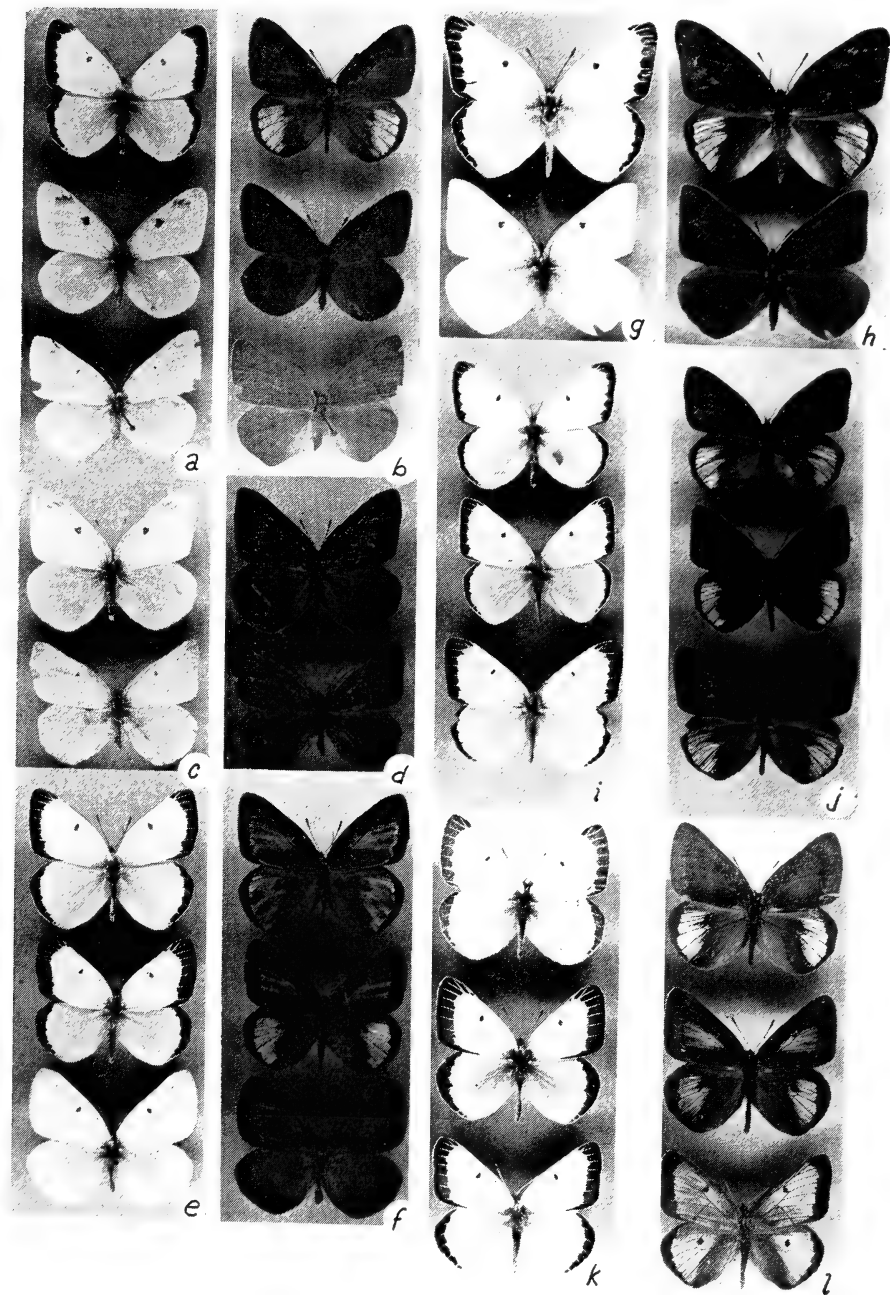
The yellow races are distinguished by lacking forewing luminosity (or exhibiting only a trace at most) under uv illumination and by having yellow (concolorous with the ground color) discal spots on the dorsal surface of the secondaries in the males. This definition differs from previous ones which included populations that have orange discal spots. Generally the orange-spotted specimens exhibit forewing luminosity.

#### YELLOW-ORANGE POPULATIONS—DISTRIBUTION

California, Idaho, Montana, Nevada (Elko, Nye, Washoe Cos.), Oregon, Utah, Washington, Wyoming, Alberta, British Columbia, Manitoba, Northwest Territories, Saskatchewan. Recently a single orange-discal-spotted male *alexandra* was collected by M. S. Fisher (Parker, Colorado) in Elbert Co., Colorado, an eastern plains region of the state. Further collecting is necessary to ascertain if this specimen is from a yellow-orange isolate with possible affinity to the Black Hills *krauthii*, or a hybrid with *philodice* or *eurytheme*. Undoubtedly other yellow-orange isolates, not shown in Fig. 2, will be found as collectors penetrate into little-collected areas.

←

Fig. 3. General extent of luminous patches as they appear on the wings of the males in the *Colias alexandra* complex. Hindwing patches in (a) yellow group; (b) orange group; (c) yellow-orange group. The discal spots, shown as open circles, are generally black in uv photographs. Forewing patches in (d) transition yellow to yellow-orange populations (submarginal band); (e) some yellow-orange populations (submarginal band and portions of some cells near veins); (f) other yellow-orange populations (central portion of wing generally reflects with some dark areas); (g) orange populations (wing reflects almost uniformly except for marginal areas).



Some of the yellow-orange races appear yellow under visible light, except that the discal spot on the dorsal surface of the hindwings is orange. Individual male specimens may show a dark yellow or a pale yellow-orange flush discally and limbally on the upper side of the secondaries and females may exhibit considerable orange. Under uv illumination, luminous patches appear on the forewings. Individuals of *C. a. astraerea* may appear to be pure yellow except for the orange discal spot, but this subspecies as a whole ranges from yellow to orange. For this reason, populations with orange discal spots in the males are classified in the yellow-orange group based upon uv patterns and not visible light (pigmentation) appearance.

Southern Alberta appears to represent a complex blend-zone region. In the area from Calgary to Banff and east of the Rocky Mountains, specimens can be taken which represent *alexandra*, *astraea*, *christina*, and *krauthii*. It is frequently possible to collect two or three good "subspecies" at the same locality. This situation is typical of the intergrading which occurs in the *alexandra* complex and is the reason for the restricted ranges shown in Fig. 1.

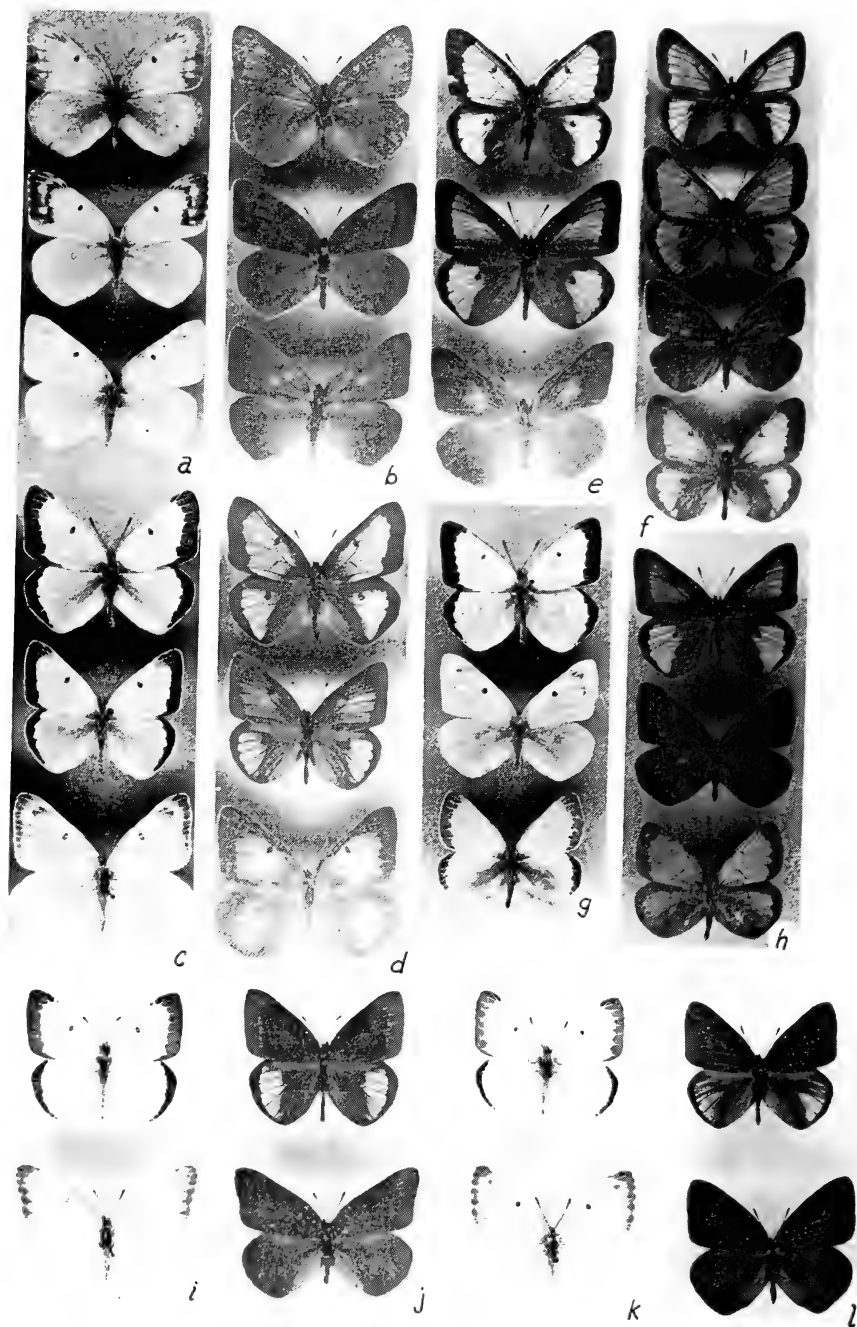
Northern Utah specimens, especially from Tooele and Wasatch Counties, tend toward both *astraea* (in the males) and *christina* (in the females). The latter frequently show an overwashed orange coloration.

Specimens of *alexandra* from Nevada have generally been determined to be subspecies *edwardsii*. A small series in the collection of the Los Angeles County Museum of Natural History taken by A. O. Shields in Jett Canyon, Toiyabe Range, Nye Co., Nevada is clearly from a yellow-orange population. The discal spots (dorsal secondaries) are orange in both sexes and distinct luminous patches show on the forewings of the males under uv light. Some specimens from the same locality are phenotypically *edwardsii*. Peter Herlan (Carson City, Nevada) has found yellow-orange populations in Elko and Washoe Counties as well. The occurrence of these isolates is as yet unexplained.

California specimens from Lassen (Blue Lake area, Warner Moun-

←

Fig. 4. Specimens of *Colias alexandra* photographed under white (left) and ultraviolet (right) light. **a & b**, *C. a. alexandra*, Albany Co., Wyoming: ♂, normal ♀, white ♀. **c & d**, ♀♀ of *C. alexandra*; top, Tooele Co., Utah; bottom, Catron Co., New Mexico. **e & f**, *C. alexandra*; top ♂, Boundary Co., Idaho; bottom pair, S of Golden, British Columbia. **g & h**, *C. alexandra*, pair from Utah: ♂ Tooele Co., ♀ Wasatch Co. **i & j**, ♂♂; top, *C. a. "emilia"*, Okanogan Co., Washington (see text); middle, *C. a. edwardsii*, Lander Co., Nevada; bottom, segregate, Apache Co., Arizona. **k & l**, ♂♂ of *C. a. astraea*; top, Sublette Co., Wyoming; middle, S of Seebee, Alberta in blend-zone region; bottom, Sheridan Co., Wyoming (orange form)



tains) and Modoc Counties show the orange discal spot in the males and considerable orange scaling in the females. Under uv light, luminous patches show on the forewings of the males.

Oregon specimens are similar, with the exception of a population from the Canyon Creek area, Ochocho Mountains, in Crook Co. The males from this region are similar to material from British Columbia, but the females show considerable dark bordering as in *occidentalis* Scudder. Some are quite similar in pattern and color to this species. Perhaps some hybridizing has occurred, but this is speculation. *C. occidentalis* is a non-reflective species.

The northern Idaho—southern British Columbia segregate is a large insect, generally larger than nomenotypical *alexandra*. This is described as a new taxon below. At first, it can be mistaken for *gigantea* Strecker because of the forewing apical rounding, but its habitat is forest clearings and roads, not bogs. McDunnough (1928) called this butterfly *Eurymus emilia*. Initially, one would place the population with the yellow races, but the discal spot is orange and the forewings exhibit luminous patches under uv illumination (Fig. 4f; Fig. 6e, f). This butterfly does not fit Edwards's description of *emilia*, and F. M. Brown (1973) has shown that *emilia* is synonymous with *edwardsii* which has page priority.

#### ORANGE POPULATIONS—DISTRIBUTION

South Dakota, Wyoming, Montana (?), North Dakota (? reported by Opler, unpublished), Alberta, Manitoba, Yukon Territory, Alaska.

A butterfly has been collected in the Yukon Territory (along the Alaska Highway) and in Alaska which appears to be a member of the *alexandra* complex (Fig. 5f-h). In many respects, it is similar to *Colias hecla* Lefebvre, but the underside and the uv reflectance pattern from the upperside place it tentatively as *alexandra*. Private correspondence with other collectors indicates that F. H. Chermock may have intended to name this population.

←

Fig. 5. Specimens of *Colias alexandra* photographed under white (a, c, g, i & k) and ultraviolet (b, d, e, f, h, j & l) light. a & b, ♀♀ of *C. a. astraea*; top, Johnson Co., Wyoming; middle and bottom, S of Seebee, Alberta in blend-zone region. c & d, *C. a. krauthii*, Lawrence Co., South Dakota; top, orange ♂; middle, ♂ showing some yellow; bottom, ♀ (note the luminous patches on the female). e, *C. a. christina*: top, ♂, Riding Mtns., Manitoba; middle and bottom, pair, S of Seebee, Alberta in blend-zone region (note slight luminous patches on forewings of ♀). f, *C. alexandra* (?); 3 ♂♂ and 1 ♀, Yukon Territory. g & h, *C. a. christina*; top, ♂; middle, ♀; both S of Seebee, Alberta in blend-zone region; *C. alexandra* (?); bottom, ♂, Steese Highway mile 111, Alaska. i & j, *C. a. harfordii*; pair, Kern Co., California. k & l, *C. a. barbara*; Santa Barbara Co., California.

Pure orange races of *alexandra* have been reported from the area near Beulah, Manitoba, and Pocolhontas, Alberta. These may be referable to the taxon *krauthii*. The Alberta specimens superficially resemble *krauthii*, but are considerably smaller.

#### Taxonomic Studies

*Colias alexandra barbara* H. Edwards, new combination

*Colias alexandra harfordii* H. Edwards, new combination

In 1877, Henry Edwards published a paper in which he proposed names for two *Colias* from California. These are the taxa *barbara* [T. L. Santa Barbara, California] and *harfordii* [T. L. Havilah, Kern Co., and Contra Costa Co., California]. They have stood as distinct species until P. A. Opler (unpublished) placed *barbara* as a subspecies of *harfordii*, although Talbot (1935) listed *barbara* as a form of *harfordii*. Edwards did indicate that both insects were related to *alexandra*.

Based upon uv photographs (Fig. 5i-l), it appears that the affinity of both butterflies is with *alexandra*. These subspecies appear to represent an intermediate situation. The uv reflectance from the forewings is reduced to a trace, as in the yellow populations, but the secondary discal spot is orange, as in the yellow-orange populations.

Additional justification for this assignment lies in range and foodplant. *C. a. edwardsii* is considered rare in California, although it is locally common in nearby Nevada (Lander Co.). Another population (previously discussed) is found locally in Lassen and Modoc Counties. Since *alexandra* is known to the north of central California, it seems odd, based upon geology, ecology and geography, that it should not occur centrally and along the coast of southern California. The southern and middle coastal areas and part of the central portion of the state are the areas in which *barbara* and *harfordii* occur. As noted earlier, *harfordii* uses *Astragalus* as a larval hostplant, which is also true of *alexandra*. Thus from the uv reflectance pattern, range, and hostplant affinity, it appears reasonable to assign *barbara* and *harfordii* to *alexandra*.

#### ***Colias alexandra columbiensis* Ferris, new subspecies**

Brown's treatment of *emilia* (1973) leaves the British Columbia race of *alexandra* without a name. The name *columbiensis*, derived from the type province, is proposed for this butterfly. This subspecies differs from other *alexandra* subspecies in that the apices of the forewings are definitely rounded suggesting *gigantea*. The uv reflection pattern in the males places this insect in the yellow-orange group. Comparison with other

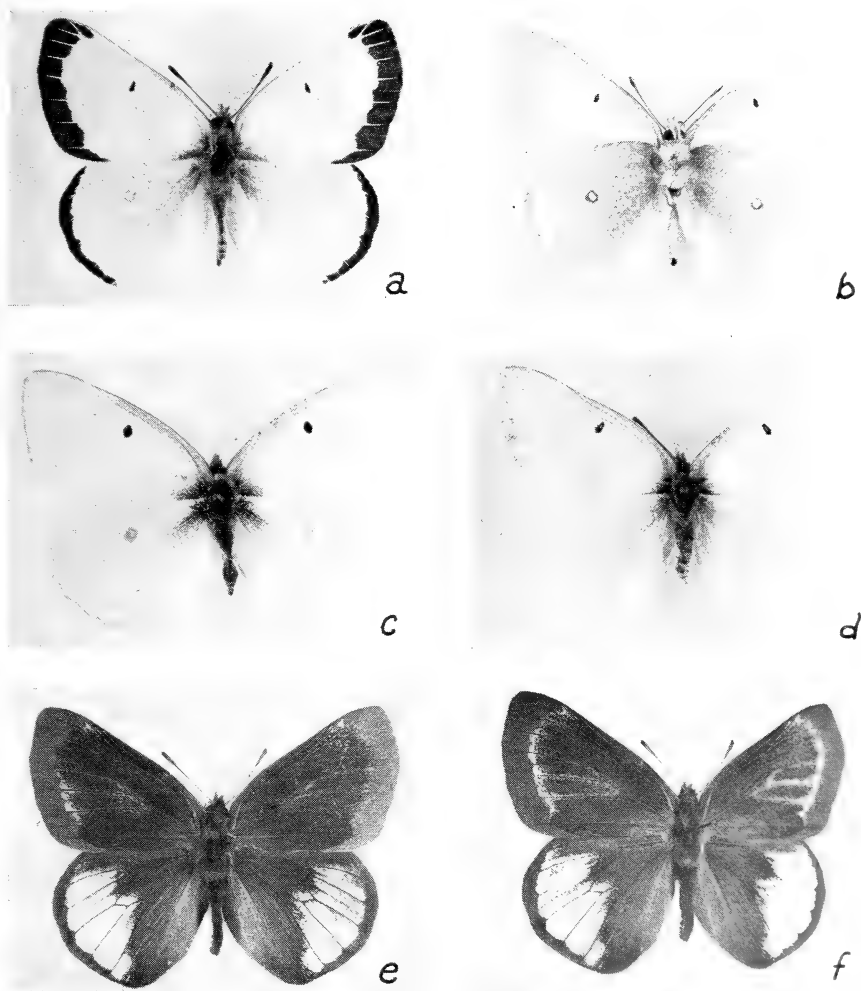


Fig. 6. *Colias alexandra columbiensis* Ferris: a, male holotype (upperside); b, same (underside); c, yellow female paratype (upperside); d, white female paratype (upperside); e, uv photograph of male holotype; f, same, but with specimen tilted to show full extent of forewing pattern on upperside.

members of this group shows that *columbiensis* differs from *christina* in that the forewings of the males show no orange color. It differs from *astraea* by being much larger, paler yellow in overall color, and is totally different in the females. *Columbiensis* females are pale yellow or white with nearly immaculate borders and generally show a large orange discal spot on the upperside of the hindwings.

In the males, the dorsal ground color is bright lemon yellow. Some specimens exhibit a dark yellow to orange flush in the discal and limbal areas of the hindwings, but do not show the pronounced orange markings which frequently occur in *astraea* and always in *christina*. The secondary discal spot is orange. The black borders are generally narrower than in nomenotypical *alexandra*. The primary cell-end spot is quite narrow. Ventrally the ground color is yellow with a slight orange flush. There is a dusting of black scales (sometimes heavy) on the secondaries. The secondary discal spot is bordered with dark pink scales and has a pearly center. Occasionally there is a satellite spot. The wing fringes are pink with some yellow as in *astraea*.

The females are dimorphic as is the case with other races of *alexandra*. Both yellow and white forms occur, as well as intermediates. The yellow females have a lemon yellow ground color frequently overwashed with pale orange, less pronounced dorsally than ventrally. In the white forms, there may be pronounced yellow-orange overwashing. Dorsally in both forms, the dark bordering varies from absent to slight. The primary cell-end spot is distinct (more so than in the males). The secondary discal spot is bright orange in the yellow forms and varies from orange to white in the white forms. Ventrally, the females are generally similar to the males, although there is a heavier overscaling of dark scales and the ground color is lighter in the white forms.

This subspecies is generally larger in size than the nominate species. The forewing costal margin length of the holotype male is 26 mm, 29 mm for the yellow female, and 28 mm for the white female shown in Fig. 6. In some males from northern Idaho, the costal margin length is 32 mm. Male specimens of *C. a. alexandra* examined from the Front Range (Rocky Mtns.) area measured 23 to 25 mm.

The holotype and two female paratypes are shown in Fig. 6. In addition, the uv reflection pattern of the holotype is presented. It is typical of the yellow-orange group.

**Type Series.** The type series consists of 6 males and 13 females. Because of the female dimorphism, no allotype is designated.

**Holotype** ♂. The specimen bears two labels. The locality label is machine printed black on white, with the exception of part of the date which is handlettered in black ink, and carries the following data: Anderson Lake/D'Arcy, B.C./17 June 1926/J. McDunnough. A second red label, machine printed in black is inscribed: *Colias alexandra/columbiensis* Ferris/Holotype Male.

**Paratypes.** 5 ♂♂, same data as holotype. 1 ♀ (white), same data as holotype. 9 ♀♀, 100 Mile House, B.C.: 28 June 1938, 4 ♀♀ (white); 29 June 1938, 1 ♀ (yellow); 30 June 1938, 3 ♀♀ (1 yellow); 4 July 1938, 1 ♀ (white), leg. J. K. Jacob and G. S. Walley. 2 ♀♀ (white) Lac la Hache, B.C., 5 July 1938, leg. G. S. Walley. 1 ♀ (white) Canin Lake, B.C., 24 June 1938, leg. G. S. Walley.

**Distribution.** This subspecies is found in British Columbia south to Washington



(Okanogan Co.) and northern Idaho (Boundary Co.). To the southeast of this region, it intergrades with *astraea* and to the south (southern Washington, Oregon, and northern California), it intergrades with *edwardsii* and possibly *harfordii*. The Canadian Rocky Mountains appear to form an effective barrier against any significant intergrading between *columbiensis* and *christina*. Specimens collected in the Bitter-root Mtns., Ravalli Co., Montana exhibit characters associated with both *astraea* and *columbiensis*.

*Colias alexandra columbiensis* is figured in Holland (1931), Plate LXVIII, figs. 22, 23, as *C. emilia*. The orange discal spot in the male is poorly reproduced. The specimens shown were collected by Greene in 1894 at Osoyoos, British Columbia and are in the Carnegie Museum collection. They came to Holland from W. H. Edwards who labeled them as *emilia*, even though they do not fit his description of the taxon. Wright (1907) also figures *emilia*, Plate XI, fig. 92, but at least two of the examples shown are probably *philodice eriphyle* Edwards.

The type series for *columbiensis* is placed in the Canadian National Collection, Ottawa, Ontario.

### CONCLUSIONS

It is suggested that the taxa associated with the *Colias alexandra* complex be arranged as follows:

- Colias alexandra alexandra* Edwards
- Colias alexandra edwardsii* Edwards
- Colias alexandra harfordii* H. Edwards
- Colias alexandra barbara* H. Edwards
- Colias alexandra columbiensis* Ferris
- Colias alexandra astraea* Edwards
- Colias alexandra christina* Edwards
- Colias alexandra krauthii* Klots

Unnamed races which possibly merit nomenclatural recognition:

- Colias alexandra* Arizona-New Mexico Segregate  
(yellow population).
- Colias alexandra* Yukon Territory-Alaska Segregate  
(orange population).

The arrangement is roughly according to pigmentation. The taxa *alberta* and *emilia* are omitted for the reasons set forth above. Other aspects of the *alexandra* complex have been treated by Ferris (1972a).

Ultraviolet reflectance photography has been used in this study to assign the various *alexandra* populations to specific color groups. It has also been used to identify *barbara* and *harfordii* as members of the *alexandra* complex.

### ACKNOWLEDGMENTS

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J. A. Legge, Jr., J. R. Mori, R. C. Priestaf, J. T. Sorensen, K. B. Tidwell, M. Toliver, and R. E. Woodley. Loan specimens from museums were supplied by J. P. Donahue, Los Angeles County Museum of Natural History and G. E. Ball and D. R. Whitehead, University of Alberta.

Mr. George Lewis of the Canadian National Collection, Ottawa, kindly provided specimens for study from British Columbia, some of which were designated in the type series for *columbiensis*. F. M. Brown and R. E. Silberglied kindly read and commented upon preliminary drafts of the paper and both generously made results of their studies on *Colias* available. A. B. Klots of the American Museum of Natural History provided collection data for Manitoba populations. Special thanks are due H. K. Clench, Carnegie Museum, for providing a copy of a scarce paper by Henry Edwards.

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## THE GENETICS OF FORE AND HINDWING COLOUR IN CROSSES BETWEEN *DANAUS CHRYSIPPUS* FROM AUSTRALIA AND FROM SIERRA LEONE (DANAIDAE)

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Unlike most warningly colored species, the butterfly *Danaus chrysippus* (L.) is known to be polymorphic in large parts of its range. Before one can understand the reason for this it is necessary to determine the genetic control of the forms. Recently we obtained a stock of *D. chrysippus* from Sydney, NSW and another from Sierra Leone. This paper gives preliminary results obtained by crossing the two races.

### MATERIALS AND METHODS

The material from Australia, which was sent to us as living butterflies by post, was monomorphic and typical f. *chrysippus* of the race *D. c. petilea* (Fig. 1a). The ground colour of these butterflies is tawny orange tending to nutbrown towards the costal margin of the forewing. The hindwing upperside is bordered by black, sometimes with a vestige of white spotting close to the hindwing border. The apical third of the forewing upperside is black, with a variable subapical bar of white spots.

The specimens from Sierra Leone, f. *alcippus*, differed from the Australian ones in that the ground colour was more orange and most of the hindwing was covered by a patch of white scaling (Fig. 1b, c). The pale areas of the forewings were of two types—those with a narrow costal border of nutbrown pigmentation similar to the Australian butterflies (Fig. 1b) and others in which the nutbrown extended over most of the forewing (Fig. 1c). There was not enough orange on the hindwing to determine whether its hue differed in the two Sierra Leone forms.

Hybrids between the two races were obtained by allowing the males

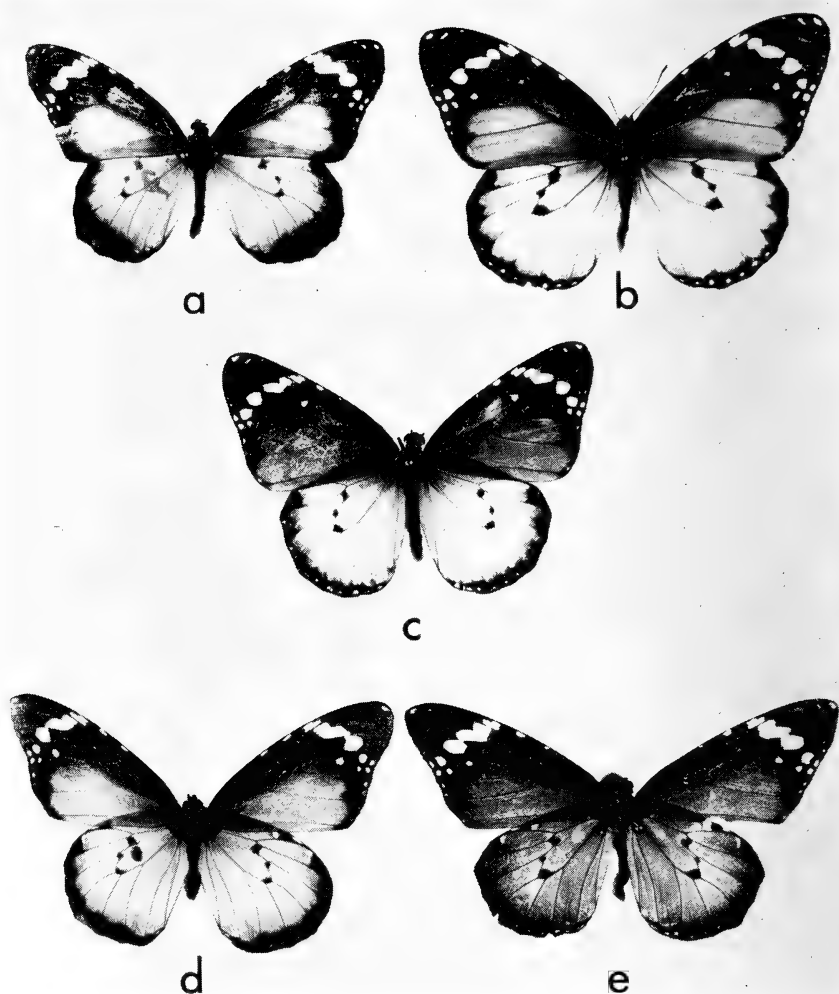


Fig. 1. Parental and  $F_1$  phenotypes: (a) *f. chrysippus*, Australia; (b) *f. alcippus*, tawny, Sierra Leone; (c) *f. alcippus*, nutbrown, Sierra Leone; (d)  $F_1$ , tawny; (e)  $F_1$ , nutbrown.

of one subspecies and the females of the other to fly freely in two heated greenhouses. Mating took place spontaneously and the females laid on a foodplant of the genus *Asclepias*. Unfortunately in these circumstances we were unable to keep the broods separate. The  $F_1$  when they emerged were allowed to mate and  $F_2$  generations were readily produced, but here again we did not keep the broods separate.

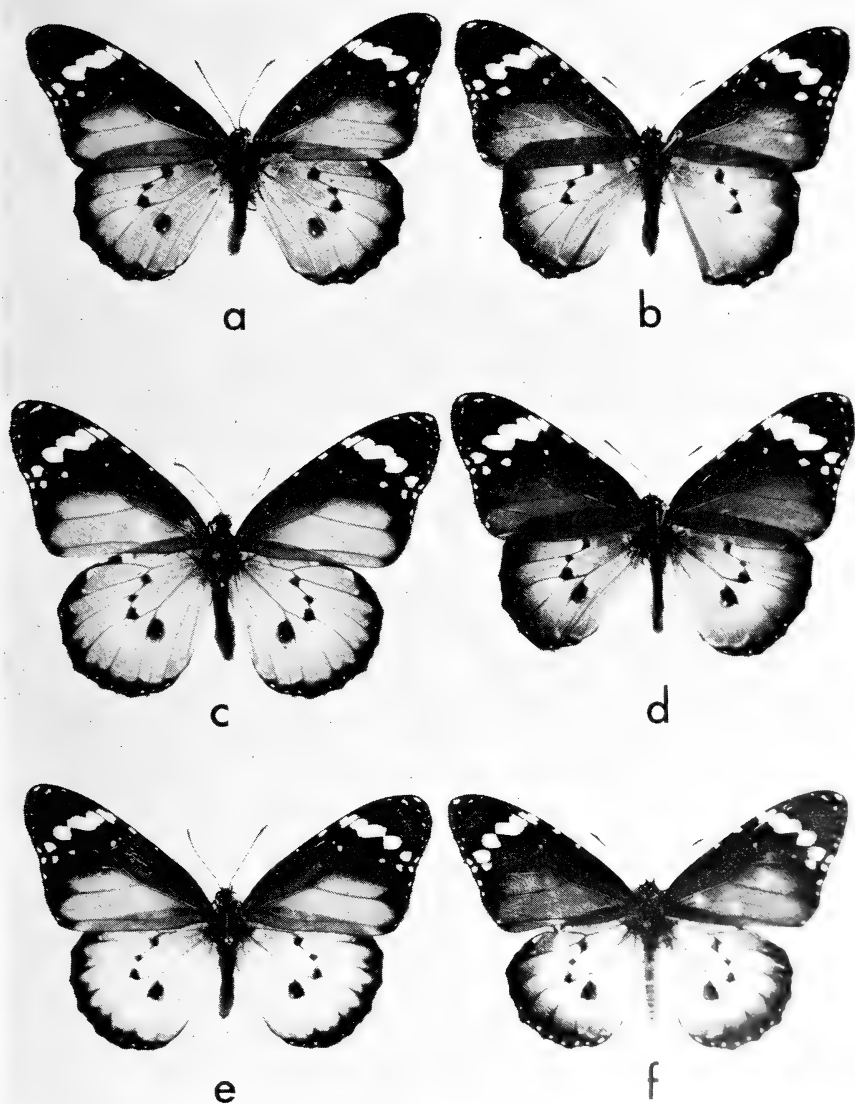


Fig. 2.  $F_2$  phenotypes: (a) *f. chrysippus*-like, tawny; (b) *f. chrysippus*-like, nutbrown; (c)  $F_1$ -like, tawny; (d)  $F_1$ -like, nutbrown; (e) *f. alcippus*-like, tawny; (f) *f. alcippus*-like, nutbrown.

TABLE 1. Phenotypes in the  $F_2$ .

Ground colour	Hindwings		
	No white	A little white ( $F_1$ -like)	White
Nutbrown	15	21	14
Tawny	58	15	20

## RESULTS

In the  $F_1$  we obtained two distinct types of progeny with respect to the ground colour of the fore and hind wings. In one the ground colour of the forewings was nutbrown and the hindwings, although slightly paler in hue, had scales which also tended towards being nutbrown (Fig. 1e). In the other the ground colour was tawny to tawny orange, the nutbrown pigmentation being confined to an area close to the costal border of the forewings (Fig. 1d). Over the hindwings of both forms there was also a scattering of white scales which was variable in extent, being undetectable in some specimens but quite obvious in others. Of 12 butterflies with a tawny ground colour 6 had no detectable white scaling whereas of 11 nutbrown individuals only 2 lacked it. The reciprocal  $F_1$ s gave comparable results.

Both types of  $F_1$  gave rise to  $F_2$ s. Among these were nutbrown individuals (Fig. 2b, d, f) and those of the tawny phenotype (Fig. 2a, c, e). There was a range of hindwing phenotypes from the Australian form without white (Fig. 1a) through intermediate forms up to a degree of white scaling found in the more extreme  $F_1$ s. With difficulty these could be divided into the parental and  $F_1$  types, but the distinction was not clear (Fig. 2a, b, c, d). In addition, there was a phenotype with a white patch on the hindwing similar to that found in the Sierra Leone grandparents (Fig. 2e, f) (*f. alcippus*). The extent of the white was variable but quite distinct from that in the other insects. Both the nutbrown and the tawny phenotypes were to be found among the offspring with the white hindwings and those lacking it (Table 1).

## DISCUSSION

Since both in the  $F_1$  and  $F_2$  generations the broods were not kept separate, we do not know the phenotype (tawny or nutbrown) of the Sierra Leone parents. However we do know that the Australian stock was monomorphic for the tawny phenotype, consequently the nutbrown form must be dominant since it segregated in a clear cut manner in the  $F_1$ .

Because the two stocks were both monomorphic with respect to the hindwing pattern we can say that white patch on the hindwing is partially recessive and completely so in some individuals. Thus in both the  $F_1$  and  $F_2$  butterflies white scaling was detectable in a higher proportion of the nutbrown phenotype than in the tawny one ( $p < 0.001$ ). In fact, the ratios in the  $F_1$  and  $F_2$  suggest that the dominance is absent in most individuals with the nutbrown phenotype but not in those with the tawny ground colour. This difference may be due to the easier detection of a few white scales on the darker background.

The presence or absence of the white patch (as distinct from white scaling) on the hindwing segregated in a clear cut manner and in a good approximation to a 3:1 ratio in the  $F_2$  (Table 1). Thus we can conclude that the presence or absence of the white patch on the hindwing is controlled by a single gene, the heterozygote being variable in expression.

Since the broods were not reared separately one cannot usefully examine the ratio of the nutbrown phenotype to the tawny one in the  $F_2$ . However, one can examine the data for evidence of linkage. We know that the nutbrown form and the white hindwing patch must both have been derived from Sierra Leone, and therefore in the presence of linkage the two loci would be in repulsion.

An examination of the ratio of white hindwing patch to its absence amongst the  $F_2$  nutbrown individuals provides no good evidence for a departure from the expected 3:1 ratio (non-white to white hindwings) on the assumption of no linkage. Furthermore, if there had been close linkage there should have been an excess of the nutbrown phenotype amongst the white hindwinged individuals.

#### SUMMARY

In the cross between *D. chrysippus* material from Australia and that from Sierra Leone, it was shown that the white hindwing area of *f. alcippus* is recessive, or nearly so, to the tawny hindwing of *f. chrysippus*, and the character is controlled in the main by a single locus.

In our Sierra Leone material there were two shades of brown on the forewings, tawny and nutbrown. The matings showed that the nutbrown coloration is dominant and extends on to the hindwing in the hybrids. It also appears to be controlled by a single locus. Segregation of the characters in the  $F_2$  does not suggest close linkage between the two loci concerned.

## A NEW *CALLITHOMIA* (*LEITHOMIA*) FROM AMAZONAS, VENEZUELA (*ITHOMIIDAE*)

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During February 1967, Harold Skinner of La Victoria and Albert Gadou of Caracas, Venezuela made a collecting expedition to the Ocamá Mission to the Waika Indians in Amazonas, Venezuela. After their return, Senor Skinner sent me a fair number of duplicate specimens. Of particular interest among these was a previously undescribed *Callithomia*, reminiscent of *Callithomia lenea* (Cramer), but with an unique forewing, unlike any other ithomine. Description as follows:

### *Callithomia* (*Leithomia*) *skinneri* Masters, new species

**Female:** Has an appearance completely distinct from that of any other *Callithomia* (Fig. 1). This is especially true of the forewings; the hindwings are very much like that of a female *Callithomia lenea*.

**Upperside of forewing:** Outlined in black. A large oval-shaped subapical patch is lemon yellow and semi-translucent. The balance of the wing is a rather uniform soft ochreous brown, slightly translucent.

**Upperside of hindwing:** Broadly outlined in black. A nearly transparent discal area has the unique shape, with the hook in cell  $M_3$ , that is characteristic of the *lenea* group of species. The discal area is surrounded by a black band that is broad caudally but quite narrow distally; it is separated from the outer margin by an ochreous orange submarginal band.

**Underside of wings:** Almost identical to uppersides except for having a number of white crescents present in the wing border. There are three well pronounced crescents on the forewing, at the termination of cells  $R_4$ ,  $R_5$  and  $M_1$ . On the hindwing there are seven of them, one at the termination of each primary cell, with the ones in cell  $M_1$  and  $M_2$  being most pronounced.

**Male:** Has the general appearance of the female. The forewings have the large oval-shaped yellow semi-translucent patch, but are otherwise more transparent than the females. The males forewings are somewhat narrower and more pointed than the females and its hindwings have a pronounced hump on the costal margin, similar to that of other males in the subgenus.

**Holotype female:** Ocamá Mission, Amazonas, Venezuela (at the junction of the Ocamá and Orinoco Rivers, approximately  $2^{\circ}30'N.$ ,  $65^{\circ}15'W.$ ), February 1967; Harold W. Skinner, collector. Length of forewing: base to tip, 28.5 mm; apex to tornus, 16 mm; center of costal margin to tornus, 15 mm. To be deposited at Carnegie Museum, Pittsburgh, Pennsylvania.

**Allotype male:** Same collecting data as holotype. Length of forewing: base to tip, 28.0 mm; apex to tornus 17 mm; center of costal margin to tornus, 13.5 mm. In the collection of Harold W. Skinner, La Victoria, Venezuela.

**Paratype:** One female, same data as holotype. In the collection of Harold Skinner. There are additional specimens in the collection of Albert Gadou, Caracas, but I have not had the opportunity to examine them.





Fig. 1. *Callithomia skinneri* new species, holotype female, Ocama Mission, Amazonas, Venezuela, February 1967. Natural scale.

The general appearance and the relatively narrow male forewings place *Callithomia skinneri* in the subgenus *Leithomia* which includes *xantho* (Felder), *methonella* (Weymer), *inturna* (Fox), *epidero* (Bates), *foxi* Masters, *zingiber* Fox, *lenea* (Cramer) and *drogheda* (Weeks). Of these, only *lenea* and *drogheda* in any way resemble *skinneri*; *skinneri* can be separated from both of them by its distinct more opaque forewings and the large oval yellow spot in them. In several respects, *drogheda* bridges the distinctions between *skinneri* and *lenea*—these three may be found ultimately to be geographic subspecies of a single species. None of the species in the nominate subgenus have a similar appearance.

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#### AN "ALBINO" *LYCAENA HELLOIDES* (LYCAENIDAE)

White or whitish specimens of *Lycaena phlaeas* Linnaeus have been recorded on both sides of the Atlantic (e.g. Fuller 1962, J. Lepid. Soc. 16: 59; Martin 1962, J. Lepid. Soc. 16: 59–60) but do not seem to be on record for *L. helloides* Boisduval, the most widespread purely Nearctic member of the genus. A fresh female *L. helloides* with the orange coloration completely replaced by creamy white on both surfaces was taken 17 April 1972 in the Putah Creek Recreation Area near Davis, Yolo Co., California. The blanching includes the normally deep reddish-orange ventral subterminal line of the hind wing. It is associated with curled or "frizzled" scales as previously reported for "albino" *L. phlaeas*. *L. helloides* is very common near Davis and shows considerable minor variation, especially in the maculation of the females.

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## A NEW SUBSPECIES OF *CALLITHOMIA HEZIA* FROM ZULIA, VENEZUELA (ITHOMIIDAE)

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Venezuelan lepidopterists have just recently begun penetrating into the Sierra de Perija, a northern offshoot of the Venezuelan Andes which forms the boundary between Colombia and Venezuela in the northwestern Venezuelan state of Zulia. Materials that have been brought back from this region have included a number of endemic subspecies and it is not surprising to find that the Perija population of *Callithomia hezia* Hewitson, a species known to display marked geographic variation, represents a distinctly marked and previously undescribed subspecies.

### *Callithomia* (*Callithomia*) *hezia perija* Masters, new subspecies

This subspecies differs from the other six subspecies of *Callithomia hezia* by having a row of three separated and relatively small yellow patches in the middle of cells  $M_1$ ,  $M_2$  and  $M_3$  on the hindwing. Subspecies *baccata* Fox and *tridactyla* Hewitson have yellow patches on the hindwing, but they are much larger and touch each other basally.

**Male** Fig. 1 A & B: Appearance readily associated with *Callithomia hezia*. Forewing length: base to apex, 35 to 37 mm. Forewing breadth: apex to tornus, 20 to 21 mm; center of costal margin to tornus, 17 to 17.5 mm.

Upperside of forewing a deep black background color with a reddish brown streak in the basal area. Upperside of hindwing light brown in background color except a black margin which greatly widens in the apical area. Pattern elements composed of opaque yellow spots which include: one or two spots in the forewing cell; a double row of forewing spots including a single spot in one of the radial cells and in cell  $M_1$ , and then two spots each in cells  $M_2$ ,  $M_3$ ,  $Cu_1$  and  $Cu_2$ ; and three relatively small, separated spots in the middle of cells  $M_1$ ,  $M_2$  and  $M_3$  on the hindwing.

Underside of both wings mirrors the appearance of the uppersides, except for the presence of five small white crescents present in the wing margins—two on the forewing and three on the hindwing.

**Male genitalia** Fig. 2 A, B & C: Shows no characteristics which might distinguish it from other subspecies of *Callithomia hezia*. The penis (Fig. 2C) is not forked; this is one of the characteristics that separates the nominate subgenus *Callithomia* Bates from subgenus *Leithomia* Masters.

**Female** Fig. 1 C, D & E. Appearance almost identical to male except for blunter and more rounded wings. Forewing length: base to apex, 35 to 38 mm. Forewing breadth: apex to tornus, 20 to 21 mm; center of costal margin to tornus, 19 to 20 mm. Yellow patches on hindwings, in two specimens, a bit larger than those of males. There is a series of six small white crescents along the ventral hindwing margin instead of three.

**HOLOTYPE male:** El Tucuco, Estado Zulia, Venezuela, September 1964, Albert Gaden collector. Length of forewing, base to tip, 35.5 mm.

**ALLOTYPE male:** El Tucuco, Estado Zulia, Venezuela, July 1968, Yuri Budokari

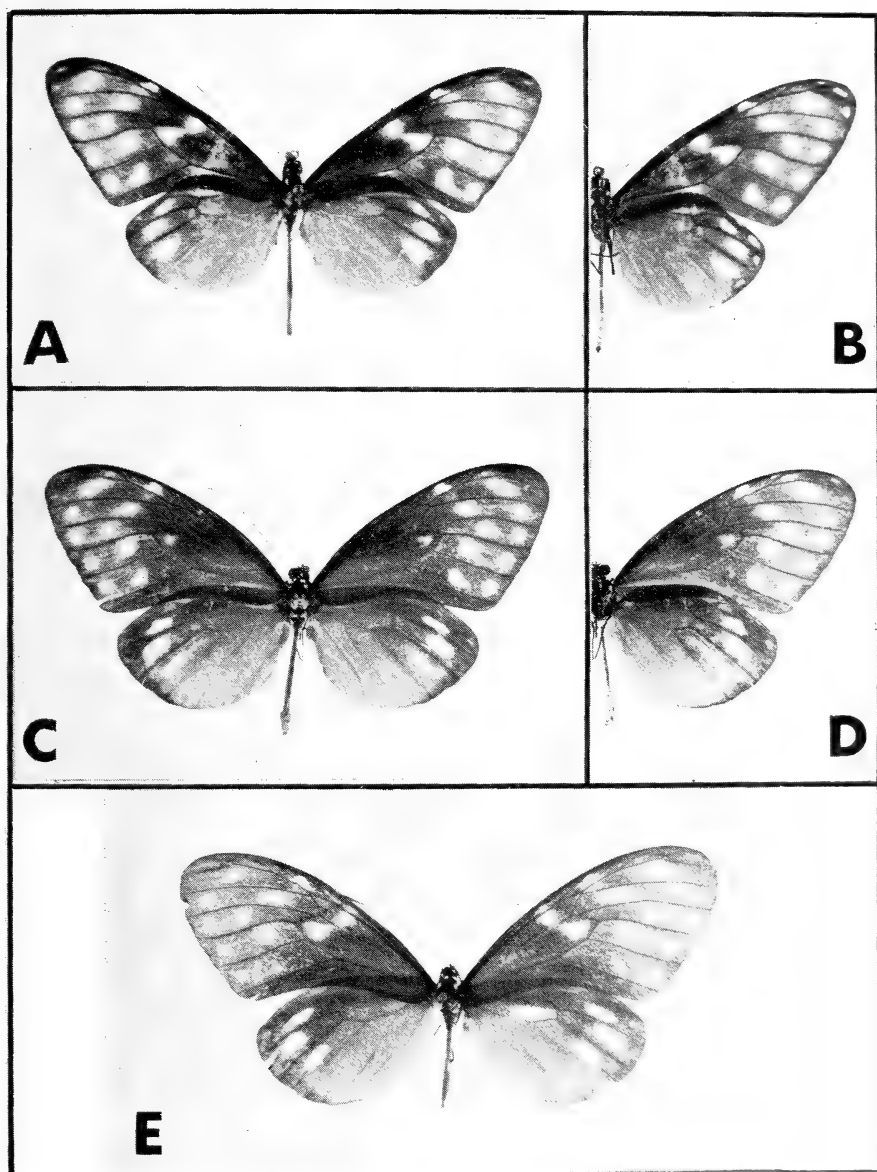


Fig. 1. *Callithomia hezia perija* new subspecies. Holotype male, El Tucuco, Zulia, Venezuela: (A) upperside, (B) underside. Allotype female, El Tucuco, Zulia, Venezuela: (C) upperside, (D) underside. Paratype female, Como del Tigre, Anduze, Colombia: (E) upperside. All specimens natural size.

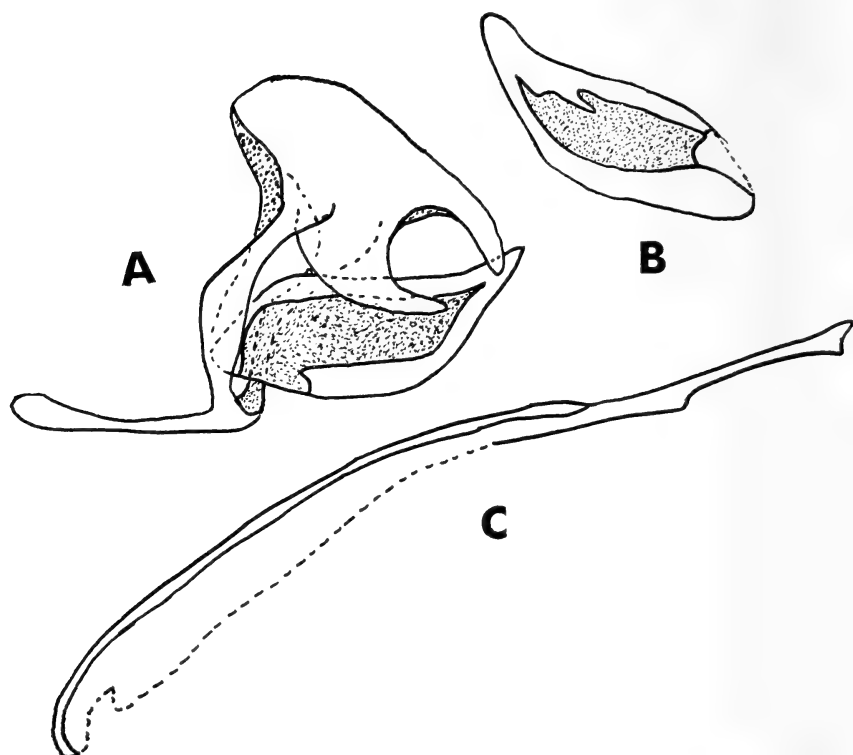


Fig. 2. Male genitalia of *Callithomia hezia perija*: (A) side view with left valve removed, (B) left valve, (C) penis.

collector. Length of forewing, base to tip, 36 mm. Holotype and allotype have been placed in the Carnegie Museum, Pittsburgh, Pennsylvania (type series number 674).

**Paratopotypes:** 3 males, 2 females in author's collection; 2 males and 2 females in collection of Harold Skinner, La Victoria, Venezuela. There are probably another two dozen specimens in other Venezuelan collections, but I have not personally examined them and am not including them in the type series. All of these are from the same locality as the holotype, various dates, 1964 to 1969, and various collectors.

**Paratype:** One female, Como del Tigre, Anduze, Colombia, Sept. 1943 (Fig. 1E) in the American Museum of Natural History, New York.

*Callithomia hezia* is a very distinct butterfly that can be confused with only one other species, its Mullerian mimic *Napeogenes peridia* (Hewitson) which is somewhat smaller. A key to the seven described subspecies of *Callithomia hezia* follows:

- |  |   |
|--|---|
| Yellow spots on hindwing .....   | 4 |
| Yellow spots not present on hindwing .....   | 2 |
| Yellow spots of forewing, including the antimarginal series, beyond the end of the cell fused into a large patch extending from the costa to Cu <sub>1</sub> ..... |   |
| ..... <i>C. hezia wellingi</i> Fox, southern Mexico and Guatemala.   |   |

- Antemarginal spots of forewing separated and never included in a patch formed by fusion of the spots ..... 3
3. Yellow antemarginal and postmedial series of forewing rather large and only narrowly separated by black which, especially in the apical part in some males, tends to be translucent .....  
*C. hezia hedila* Godman & Salvin, Guatemala and Honduras.
- Yellow antemarginal spots of forewing smaller than postmedian spots, always well separated by opaque black, but the postmedial series sometimes tending to fuse with the yellow spots in the end of the cell .....  
*C. hezia smalli* Fox, Coclé Province, Panama.
- All yellow spots on the forewing tiny and well separated from each other .....  
*C. hezia hezia* Hewitson, Nicaragua, Costa Rica and Panama.
4. Yellow spots of the hindwings only slightly larger than those of the forewings and discretely separated from each other .....  
*C. hezia perija* Masters, Sierra de Perija, Venezuela and Colombia.
- Yellow spots of the hindwings large, broad and fused together basally, but present in a single series ..... *C. hezia tridactyla* Hewitson, Colombia.
- Yellow spots of the hindwings large, broad and fused together basally, but present in a double series with an outer marginal row of spots present .....  
*C. hezia baccata* Fox, Peru.

#### SOME FIELD NOTES ON *ISOPARCE CUPRESSI* BDV. (SPHINGIDAE)

During a collecting trip to the Wedge Plantation near McClellanville, Charleston County, South Carolina in mid-September of 1972, I had the opportunity to investigate the life histories of some of the local Lepidoptera. The larval habits of the sphingid, *Isoparce cupressi* Bdv., were of particular interest to me since my host, Dr. R. B. Dominick, had successfully reared a brood of this species ex-ovo on *Taxodium distichum* L. (Bald Cypress) in the late summer of 1971. A suspected habitat of the species, a small swamp surrounded by *T. distichum* and located near the Wedge Laboratory, was surveyed, and several well exposed and isolated trees of the foodplant were chosen for examination.

Concentrated searching of the lower, accessible branches of eight large cypress trees yielded 15 larvae—one 2nd instar, five 3rd instar, seven 4th instar, and two 5th instar larvae. Six of these were in the process of molting when found. All but one of the larvae were on the undersides of the branches of the foodplant, from approximately four to seven feet off the ground. The 2nd and 3rd instar larvae were always situated near the ends of the branches, on the midribs of the terminal pinnae. The location of the 4th instar larvae was usually in the middle of the branches, also on the midribs of the pinnae. A large and nearly mature 5th instar larva, was found resting in the woody crotch of two branches. Finally, the other 5th instar larva, covered with parasitic cocoons, was discovered sitting on the top of a dead branch, moribund and obviously near death.

Two viable ova and several hatched eggshells were collected on the undersides of the terminal needles of the *Taxodium* branches. Since these were always found singly and randomly deposited, it appears likely that this is the natural mode of oviposition.

Numerous jumping spiders and harvestmen were seen during the daily examinations of the cypress branches. Their suspected predatory behavior was confirmed when a small grey salticid was observed feeding on a wriggling 3rd instar *cupressi* larva that it had obviously just captured. Judging by the large numbers seen, it

seems logical to assume that these arachnids contribute considerably to the attrition of this sphingid's early stages.

Six of the fourteen larvae later produced parasites—a dipterous maggot emerged from a 3rd instar larva, while five late 5th instar larvae produced numerous braconid-like parasites. Also, several dried corpses of *cupressi* larvae were seen on the branches, with emerged parasitic cocoons found spun in a silken mass at the base of the dead larvae.

To assess the feeding habits and density of *I. cupressi* larvae, I placed an old bedsheet underneath a number of cypress trees. Each morning I examined this sheet, and found it covered with large amounts of lepidopterous larval frass. Since there are no other known *Taxodium*-feeding species whose larvae would be as large as *cupressi*, it is assumed that most of the droppings were from this species. Almost all of it was identical in color, form, size, and texture to that deposited by the *cupressi* larvae feeding in captivity. Often there were concentrations of large frass pellets on the sheet, but searching the lower branches just above these areas revealed no larvae. It appears that most of this excreta had filtered down from *cupressi* larvae on the higher branches. Further, the ground beneath every landlocked *T. distichum* tree on the Wedge grounds indicated the presence of *cupressi* in the form of these large pellets of frass. The sheet was shaken clean each morning, and then moved to another nearby cypress tree. While the sheet was checked at frequent intervals, almost no new droppings were deposited during the day. However, the following morning invariably revealed the sheet once again covered with quantities of *cupressi*-like frass. This evidence supports the hypothesis of Bates (1928, Florida Entomol. 12: 20-21), that *I. cupressi* larvae feed at night. It seems likely that, at least around the Wedge Plantation, the higher cypress branches support healthy populations of *cupressi* larvae. Searching these higher branches at night with a flashlight, and with a ladder during the day, was unsuccessful.

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### INTERESTING FLORIDA BUTTERFLY RECORDS

The records below represent either range extensions or reinforcements of older records as published by Kimball (1965, The Lepidoptera of Florida. Gainesville. 363p.) and Clench (1970, J. Lepid. Soc. 24: 240-244). Checklist numbers are those of dos Passos (1964, Mem. Lepid. Soc. 1) and the nomenclature also follows his work. In several cases, primarily those records from the early 1960's, no specimens were taken or the few secured have been destroyed. Therefore, the data in those instances are of a more general nature. I would like to offer a special thanks to Mr. D. W. Bryne who provided support and encouragement during the period that these records were being established.

83. *Problema byssus* (Edwards). Range extension. In the early 1960's this Skipper could be found in both north Tampa, Hillsborough Co., and at Bishop's Harbor, Manatee Co.

188b. *Staphylus mazans hayhurstii* (Edwards). Range extension. Ozelto, Citrus Co.: 5 September 1970 (5 ♂♂). This represents a substantial northward extension on the west coast of Florida. The previous records (Kimball) stopped at Sanibel Island, Lee Co.

218. *Urbanus dorantes dorantes* (Stoll). Range extension. Caxambas, Marco Island, Collier Co.: 17 October 1970 (1 ♂). Branchton, Hillsborough Co.: 29 January 1972 (1 ♀) and 5 April 1972 (1 ♀). The two specimens from Branchton were taken in open areas within a forested area and represent a one hundred and thirty mile northward range extension over previous records (Clench). This could

be only a temporary extension however. The winter of 1971-72 was the warmest in many years and could be the reason *dorantes* suddenly appeared this far north in Florida. A normal winter season with numerous days around the freezing mark could well result in elimination of the species from this region.

233. *Polygonus leo* (Gmelin). New locale. Caxambas, Marco Island, Collier Co.: 17 October 1970 (1 ♂). This makes more continuous geographically the records on the Florida west coast.

274b. *Appias drusilla neumogenii* (Skinner). New locale. Casey Key, Sarasota Co.: 6 July 1963 (1 ♂). This capture reinforces an older, uncertain record from the same area (Kimball). Also, although I found this species uncommon at Key Largo, Monroe Co., in May of 1971, when I returned later in August of that year I found it to be not only abundant but also outside its normal hammock environment visiting flowers freely in the bright, open, roadside areas.

307a. *Phoebis statira floridensis* (Neumoegen). New locale. Bishop's Harbor, Manatee Co.: 27 January 1972 (1 ♀).

308. *Kricogonia lyside* (Godart). Range extension. Casey Key, Sarasota Co.: 6 July 1963 (1 ♂). This individual, taken at the blossoms of *Bidens pilosa* Linnaeus, represents a considerable northward range extension.

525a. *Anartia jatrophae guantanamo* Munroe. Range extension. In the early 1960's numerous individuals of this species were taken at Chassahowitzka, Citrus Co. The most northerly locale previously recorded on the Florida west coast was Tampa (Kimball).

554a. *Phyciodes frisia frisia* (Poey). South Bay, Palm Beach Co.: 21 August 1971 (1 ♂). This is one of the few records for the species north of Dade and Monroe Counties.

639a. *Euptychia gemma gemma* (Hubner). Range extension. In the early 1960's this satyr could be found sparingly but consistently at Chassahowitzka, Citrus Co. Also, a colony was discovered at Branchton, Hillsborough Co., in 1972 with the species being not uncommon from 20 March through at least 6 April. Moist, grassy areas within woods are preferred.

646b. *Euptychia cymela viola* (Maynard). Range extension. A colony of this species was discovered near Branchton, Hillsborough Co., with individuals on the wing from at least 12 March through 17 April in 1971. The habitat consists of an oak woods surrounded by swampy cypress stands.

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#### A NEW SPECIMEN OF *CYNTHIA ANNABELLA* "AB. MUELLERI" FROM CALIFORNIA (NYMPHALIDAE)

A male *Cynthia annabella* Field (= *Vanessa carye* auct.) virtually identical with one of "ab. *muelleri*" figured by Gunder (1929, Pan-Pac. Entomol. 6: 9, pl. 17) was taken on 10 May 1972, 2½ mi. NE Davis, Yolo Co., California. This phenotype, with various minor modifications (cf. Gunder 1927, Entomol. News 38: 263-271, pls. 5-10), has now been found between 20 and 30 times in *C. annabella* throughout California. If it has a genetic basis—as suggested by several reported clusters of captures—its incidence is probably too high to be ascribed to recurrent mutation alone. Extremely similar phenotypes are recorded in *Cynthia cardui* Linnaeus (Gunder, 1927) and *C. virginiensis* (Drury) (cf. Clark & Clark, 1951 Butterflies of Virginia, pl. 30).

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## BOOK REVIEW

TROPICAL BUTTERFLIES, by D. F. OWEN. 1971. 214 p., 40 plates. Clarendon Press, Oxford, England. \$11.50.

Perhaps because "Tropical Butterflies" is ubiquitous, the book is subtitled, "The ecology and behavior of butterflies in the tropics with special reference to African species." The emphasis of the author is summed up even better by two statements in the preface: "... this book ... is mainly about African butterflies, because I know more about them than about the butterflies of other tropical regions," and, "I advocate throughout the study of living butterflies in their natural environments, and although I am not against building up a collection, I would rather see collectors devote some of their energy to finding out more about living butterflies."

Thus, we have a book consisting of extensive discourse on ecology and behavior with only scant references to taxonomy, identification, collecting and mounting techniques, etc. This is very good, for the author is concentrating on those subjects usually neglected in "butterfly books." Some representative chapter titles include: classification and zoogeography, life histories, population ecology, population genetics, mimicry, evolution and conservation. The text is concise, well written, and amply illustrated with excellent text figures and photographic plates. There is an index and an extensive bibliography.

The author has spent eight years studying butterflies in Africa and much of the text is from his personal experiences, including an extensive treatment of the population biology of *Acraea encedon* which has been his major research interest. Many of his observations were made in a small garden in Freetown, Sierra Leone where he took about 300 species. This should suggest that elaborate trips into the bush are not essential for tropical collecting. Some chapters, such as the one dealing with mimicry, take the form of reviews of contemporary research and publication. Although most of the exemplification is taken from the African fauna, it is pertinent to pan-tropical situations and, in fact, much of it to temperate regions as well. The species diversity of the tropical butterfly fauna is treated in detail and numerous comparisons are given with temperate faunas. Seasonal forms, which are most pronounced in Africa, is the only other purely tropical phenomenon which is discussed in detail.

Without reservation, I regard the book as excellent. For anybody intending to collect in the tropics, the book would be a tremendous asset. It is not necessary to have any interest in tropical butterflies, however, in order to benefit from the book because the emphasis is on the ecology and behavior of butterflies rather than on the tropics. I hope that everyone who reads the book will retain some of the author's insights regarding the study of living butterflies. I am sure that this will result in more meaningful field work whether one lives in Africa, elsewhere in the tropics, in temperate regions, or even in the arctic.

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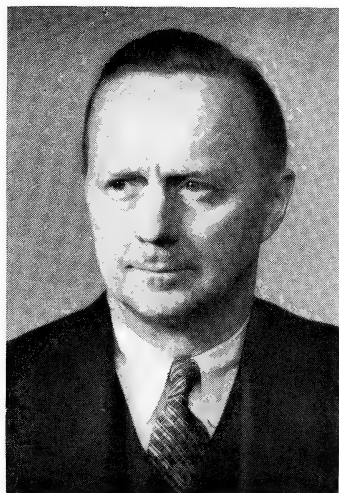
NOTES AND NEWS

As a result of the recent election, it is a pleasure to announce that F. Martin Brown and Cyril F. dos Passos were overwhelmingly approved by the membership as honorary life members of the Lepidopterists' Society. The newly elected officers of the Society are listed inside the front cover. In addition, Dr. Frederick H. Rindge was elected as the Jordan Medal Representative (see Vol. 26, p. 208), and the proposed constitutional amendments (see Vol. 26, p. 203) were passed.



## OBITUARY

ALVAH PETERSON (1888-1972)



Dr. Alvah Peterson, well known entomologist and lepidopterist, died on Monday, September 11, 1972, at the Ohio State University Hospital.

Dr. Peterson was responsible for many publications during his long career. His first major work was, "The Head-Capsule and Mouthparts of Diptera," published as an Illinois Biological Monograph in 1916. He then launched into research and the publication of many papers on economically important insects while he was with the Department of Entomology, Rutgers University (1916-1925) and the United States Department of Agriculture (1925-1928). Dr. Peterson left the Department of Agriculture in 1928 to become Professor of Entomology at Ohio State University, a position he held until retirement. It was while at Ohio State University that he completed the works that most lepidopterists will remember him for. These include *Larvae of Insects*, *Entomological Techniques*, and numerous papers on lepidopteran eggs. His two-volume work *Larvae of Insects* is used throughout the world as the basic work for the identification of immature insects. Interestingly, his pioneer work on insect eggs was done after his retirement from Ohio State University.

Dr. Peterson was a member of the Entomological Society of America where he served as national president. He also had the distinction of being the Society's first member to be elected to an honorary membership. He served as consultant or visiting professor of Entomology at

Michigan State, the University of Arizona, Oregon State, the University of Florida, and the University of Minnesota.

Besides his scientific accomplishments, Dr. Peterson was very well liked by all who knew him, especially his students to whom he always gave generously of his time and help. His passing is mourned by all who knew him.

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Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Contributors should prepare manuscripts according to the following instructions.

**Text:** Manuscripts should be submitted in *duplicate*, and must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white,  $8\frac{1}{2} \times 11$  inch paper. Titles should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name*, with *authors* of zoological names. Insect measurements should be given in *metric units*; times should be given in terms of the *24-hour clock* (e.g. 0930, not 9:30 AM). Underline only where *italics* are intended. References to footnotes should be numbered consecutively, and the footnotes typed on a separate sheet.

**Literature Cited:** References in the text of articles should be given as, Sheppard (1959) or (Sheppard 1959, 1961a, 1961b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

SHEPPARD, P. M. 1959. Natural Selection and Heredity. 2nd. ed. Hutchinson, London. 209 p.

——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. Adv. Genet. 10: 165-216.

In the case of general notes, references should be given in the text as, Sheppard (1961, Adv. Genet. 10: 165-216) or (Sheppard 1961, Sym. Roy. Entomol. Soc. London 1: 23-30).

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Address all correspondence relating to the *Journal* to the editor. Material not intended for permanent record, such as current events and notices, should be sent to the editor of the *News*: Dr. C. V. Covell, Department of Biology, University of Louisville, Louisville, Kentucky 40208.

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by CYRIL F. DOS PASSOS

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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## LEPIDOPTERA FEEDING AT PUDDLE-MARGINS, DUNG, AND CARRION

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Butterflies are often seen feeding at the margins of small puddles, sometimes in considerable numbers, and it is known also that certain species are found at dung and at carrion. In the summers of 1970 and 1971, in the course of other field work, I was able to make some observations on these habits, and came to the conclusion that they are closely related expressions of the same phenomenon. I also found that these feeding sites are well frequented not only by day but also at night, by moths of at least five families. The observations were made at Black Lake in North Burgess Township, some fifteen miles south of Perth, Ontario, along field tracks through former pasture land and the adjacent mixed hardwood and swampy areas.

### Observations by Day

A list of species observed feeding at the margins of puddles by day is given below. For every specimen involved, it was clearly established that the proboscis was extended in the feeding position. Perhaps, in all, twice as many species were seen beside the puddles, but many individuals could not be approached for critical examination.

NYMPHALIDAE. *Speyeria cybele* Fab.; *Boloria bellona* Fab.; *Phyciodes tharos* Drury; *Polygonia comma* Harris; *Vanessa virginiensis* Drur. 1859; *P. clypeus* Cramer.

LYCAENIDAE. *Harkenclenus titus* Fab.; *Feniseca tarquinius* Fab.; *Lycaena phlaeas* L.; *Celastrina argiolus* L.

PIERIDAE. *Colias philodice* Godt.; *Pieris rapae* L.

HESPERIIDAE. *Erynnis lucilius* Scudder and Burgeon; *E. icarus* Latr.; *P. peckius* Kirby; *P. mystic* Scudder; *Wallengrenia calceolus* Latr.

PYRALIDAE. *Pyrausta orphrisalis* Wlk.; *Desmia frugalis* L.

Fifty-two individuals of these species were examined for sex; all were males with the exception of 2 (out of 5) specimens of *Lycaena phlaeas*.

The probing butterflies were found, with few exceptions, around four small groups of puddles situated at intervals of a quarter mile or so along the field road. At three of these stations a swampy ditch with open water ran along one or both sides of the track for a considerable distance, and all along the roadway there were patches of thick grassy vegetation where dew might remain throughout the forenoon. Often many butterflies were congregated at the puddles for several hours before the dew had dissipated. Thus it seemed unlikely, from the outset, that the basic function of puddle-visiting was to obtain water, which was usually in ample daily supply on a wide scale.

The butterflies probed, typically, at the moist soil around the margins of the puddles, not at the free water itself. They avoided standing on the moister regions, and the skippers in particular often perched on a dry pebble or twig and, working their way towards the edge, probed with the tongue at the damp mud below. The mud remained attractive, though not so strongly, even as it dried and ceased to be visibly moist; and on occasion *Lycaena phlaeas* and several of the nymphalids and skippers were seen probing industriously at normally dry soil more than a week after any visible puddle had disappeared. (It is always important, in these situations, to establish that the butterfly is engaged in feeding, and not merely in sunning—the more so as nymphalids, when they are feeding on the ground, usually hold the wings open.) On one occasion *Vanessa virginiensis* was encountered probing steadily among dry duff and topsoil beneath pine trees; and *Feniseca tarquinius* often probed for long periods over slightly moist rotten wood lying on the ground.

Nevertheless, the presence of the puddle clearly increased the attractiveness of the site, and a depression visited only by an occasional individual in dry weather became a centre of interest for six or eight species when water was again available. The puddles, of course, all lay in depressions, and were filled from time to time by water seeping or draining down the pathway on either side. Probably they represented areas of concentration of organic debris and solutes, and it seems likely that this was the real source of their attractiveness. The decaying organic material probably gave off odorous substances, able to attract or arrest passing insects, especially when moist; and its attractiveness would decrease as it became dry.

As already mentioned, butterflies are sometimes observed also on dung and on carrion. When horse dung, and still more when recently killed frogs or turtles or small mammals were added to a puddle, the numbers

of insects visiting it and probing increased very considerably. The individuals probing directly at the dung or carrion were remarkably stable—especially those on carrion, which were so intent on probing that they could usually be approached and picked up with the fingers. Specimens of *Harknclenus titus*, *Celastrina argiolus*, *Feniseca tarquinius*, *Phyciodes tharos*, *Vanessa virginiensis* and *Limenitis arthemis* were collected in this way from a dead frog. At an ordinary puddle, the butterflies move around fairly readily, probing repeatedly with the proboscis as they gradually shift their position near the margin. On encountering a piece of dung they are at once stabilized, and continue feeding there for a considerable period; and still more so on encountering carrion. It seems that the ordinary but inevitably somewhat enriched puddle, the horse dung, and the dead animals represent successively higher levels of the same stimuli. The order of preference was the same for all species present in significant numbers, but no additional species, not found at the ordinary puddles, visited the dung or carrion.

Just as some butterflies probed at dry mud that could scarcely have yielded any significant amount of liquid, so also, occasionally, they visited and probed at desiccated pieces of dung. A specimen of *Polygonia* (? *interrogationis* Fab.) explored a dry gunny sack that had contained horse manure for upwards of 20 minutes, all the time probing between the fibres with the proboscis. *Lycaena phlaeas* also was seen at dry horse dung; and *Erynnis* sp. landed and probed repeatedly on a dry bird dropping on a bare rock exposed to the sun. The lepidopteran proboscis is adapted for taking up liquids only, and it seemed therefore of interest to make some closer observation of these attempts to feed on dry materials.

Specimens of *Lycaena phlaeas* (3 ♂♂; 1 ♀), *Phyciodes tharos*, and *Polygonia comma*, held in glass vials were offered dry clippings of skin and muscle from a dead frog, and in direct sunlight they probed readily with the extended tongue. The manner in which Lepidoptera feed on dry sugar-containing materials is being described elsewhere (Downes, in prep.), and the feeding process on other dry materials is very similar. Briefly, the tongue is extended and the anterior (dorsal) face of the apical region—the only part used for food intake; the main length of the proboscis merely enabling the insect to probe at a distance—is applied closely to the surface of the skin clipping. The seam between the two galeae that make up the tongue opens slightly and a pulse of saliva is released along the whole length of the apical region. This is applied to the food. The saliva penetrates among the fibres of the skin and muscle for a distance of perhaps five tongues' width, and is then quickly

withdrawn into the tongue, by suction exerted by the muscles of the cibarium. At a satisfactory feeding point the cycle of outflow and withdrawal of saliva may be repeated 10-20 times in as many seconds, and the tongue then probes again nearby. Thus the surface of the food is repeatedly washed with saliva, and soluble materials liquefied and imbibed. There can be little doubt that this is what happens in nature when butterflies probe at dry mud or horse dung. Somewhat similarly, individuals of *Feniseca tarquinius* and *Danaus plexippus* (L.) have been observed salivating and re-imbibing on the skin of the hand, at dry sweat and on areas that had earlier been lightly painted with sodium chloride. It thus appears that Lepidoptera may obtain not only sugars but also other nutrients from dry deposits, by washing them out with saliva. [Unfortunately none of the skipper butterflies were observed in detail when feeding on dry materials. There are several records in the literature of hesperids moistening the food by a droplet of liquid from the anus, and then imbibing (see Norris, 1936). I think, however, that this represents a special case.]

The requirement that is satisfied by feeding at puddle-margins and the related sources remains unknown. The obvious first suggestion is a need for protein or amino acids. There seems, however, to be no indication in the literature of the occurrence of proteinases in the digestive system of Lepidoptera; and it would, moreover, be remarkable that a requirement for nitrogen should be almost restricted to the male sex. Other possibilities are a requirement for salt, or some trace substance for which the male, with his probably greater flight activity, has more need. The same puddles were visited also by many kinds of small bees and bombyliid flies; perhaps, therefore, a number of specialized nectar feeding insects have certain requirements that floral nectar does not supply.

A few observations were made on the discovery of the puddle and the choice of the feeding point. The puddle area seemed to be encountered by accident during general flight and then, probably at rather close range, the increase in concentration of odorous substances led to settling on the ground in the general vicinity of a feeding area. A satisfactory feeding point was discovered by random walking, probing meantime at the surface with the proboscis; and similar random movements, as already noted, led eventually to the feeding points on dung or carrion where the insect became more fully stabilized. The discovery of the feeding point, of whatever grade of stability, seemed to be mainly 'accidental,' by unoriented questing.

More specific stimuli may sometimes be involved. The skippers, both

*Erynnis* and *Polites*, often landed directly onto small whitish patches of bird droppings (which are evidently a favourite feeding site in this family), and sometimes also onto horse dung. The precision of landing suggested an element of visual control as the approach was completed. Occasionally *Celastrina argiolus* also was seen to land directly on bird droppings. The sulphur butterflies often landed within inches of other individuals, evidently recognising them by sight; and in this way, probably, the familiar aggregations of puddle-feeding butterflies are built up.

### Observations at Night

As noted above, two species of Pyralidae were occasionally seen feeding with the butterflies at the puddles. The puddle-visiting habit has seldom been recorded except for the Rhopalocera, and this observation suggested that it would be interesting to visit the sites by night. On the first night, 8 July 1971, about an hour after dark, upward of fifty moths, mostly Geometridae and Pyralidae but also a few Noctuidae, Pterophoridae and Tortricidae, were seen at the puddles. It was curious and striking to encounter six or eight conspicuous white or yellow pyralids and geometrids perched on the shell of a crushed turtle, busily probing with the proboscis between the fractures in the carapace. Good numbers were seen also on two occasions later in the month, but few or none on four other nights.

The moths also were stabilized more strongly by carrion than by the normal damp margin of the puddle. Except for a few of the pyralids, the moths were generally much more quiescent while feeding than the daytime butterflies and usually could be collected directly into individual vials. All the geometrids, except for *Hydria prunivorata*, sat with the wings closed, butterfly fashion, above the back. Most of the species encountered were long-tongued forms that are probably also nectar feeders, except for the tortricids, which perhaps feed on honeydew, and the large noctuid *Euthisanotia grata*. This latter species has, for a noctuid, a quite short tongue, and to feed it crouched close to the mud with the wings widely spread out to the sides; in this position it evidently mimics a large variegated bird dropping.

As with the daytime visitors, the moths were very predominantly males; the single specimen of *Tarachidia erastrionides* and one of the two *Blepharomastix ranalis* were the only females among 63 specimens collected and sexed. All these specimens had been clearly observed, before capture, with the proboscis extended and probing at the mud or carrion. The list of species represented is given below; but again other species were seen in apparent feeding situations but were not collected because the observation could not be satisfactorily completed.

NOCTUIDAE. *Leuconycta diptheroides* Gn.; *Euthisanotia grata* Fab.; *Tarachidia erastrionides* Gn.;

GEOMETRIDAE. *Xystrota rubromarginaria* Pack.; *Scopula ancillata* Hlst.; *S. enucleata* Gn.; *Euphyia centrostrigaria* Woll.; *Eupithecia misturata frostiata* Swett.; *Lygris diversilineata* Hb.; *Hydria prunivora* Ferg.; *Euchlaena johnsonaria* Fitch; *Itame exauspicata* Wlk.; *Xanthotype urticaria* Swett.; *V. sospeta* Drury; *Sicya macularia* Hlst.; *Nematocampa limbata* Haw.; *Anacamptodes vellivolata* Hlst.

PYRALIDAE. *Argyria nivalis* Drury; *Crambus* sp.; *Blepharomastix ranalis* Gn.; *Acrobasis* sp.; *Tetralopha* sp.; *Mecyna submedialis* Grt.; *Herpetogramma pertextalis* Led.; *Pantographa limata* G. and R.; *Pyrausta orphrisalis* Wlk.; *Desmia funeralis* Hb.

PTEROPHORIDAE. *Platyptilia pallidactyla* Haw.

TORTRICIDAE. *Sparganothis* sp. nr. *putnamana* Free.; *Argyrotaenia quadrifasciana* Fern.; *Argyrotoxa semipurpurana* Kft.; *Choristoneura rosaceana* Harris.

### Conclusions from Observations

The chief results that emerge from these observations are as follows.

1. The habit of feeding at puddle-margins is not, basically, related to water requirements, though it may of course often be the way the need for water is supplied. Puddle-visiting occurs even when ordinary water is plentiful nearby, and the same species may (a) sometimes probe also at the dry sites of former puddles, and (b) prefer dung and carrion to the ordinary puddle-margin. The tested species fed from dry materials by washing them with repeated pulses of saliva discharged from the apical region of the proboscis and then re-imbibing.

2. Representatives of most of the main groups of butterflies found in the study area were observed at the puddles/dung/carrion. At night the same feeding sites were visited by moths, principally Geometridae and Pyralidae but also a few Noctuidae, Tortricidae and Pterophoridae. Both the day- and night-time visitors were very predominantly (approx. 96%) males.

3. The nutritional requirement satisfied by probing at puddles/dung/carrion is not known, but is unlikely to be a requirement for protein. The habit is presumably quite distinct from the sugar-feeding habit general in Lepidoptera, and probably represents a secondary development related to a specialized need in certain families or under certain circumstances.

4. The feeding areas are discovered probably by a response to odour while in flight. The precise point of feeding is apparently reached, after landing, by random questing. There may also be visual responses to already established insects, this tending to build up aggregations, and sometimes perhaps to special feeding sites, such as bird droppings.

### Discussion

Many notes have been written on these aspects of the feeding habits of adult Lepidoptera, but they are widely scattered and mostly brief.

An extensive review was published by Norris (1936), and that paper remains the basic reference. Initially Norris treats the puddle-visiting habit as water drinking; but numerous instances of feeding at dung, sweat, salt, the moisture exuding from the eyes of cattle, and such like, are then assembled, and it is pointed out that many puddle and riverside drinking places are contaminated with animal excreta. It is noted that the excreta or soil that the insects visit is sometimes quite dry; and that drinking areas are often restricted to contaminated sites even when cleaner water is abundantly available. Norris concludes, "The problem of water-drinking in the Lepidoptera is [thus] inextricably confused with that of their attraction to dung and sweat . . . There is reason to believe that practically all water-drinking may be primarily due to such attraction." My own observations emphasise even further the significance of dung and carrion, which are more powerful attractants (or arrestants) than lightly contaminated moist soil. The insects probed at such materials even in the dry state and the significant substances were presumably extracted by the saliva that they were seen to discharge and re-imbibe. It seems clear that decaying animal materials must have a significance, and presumably supply a nutritional need, over and above any requirement for water as such.

Norris' records nearly all show a great preponderance of males, similar to that noted above. Females are well represented (about one third of the total) only among the Noctuidae feeding at sweat-impregnated clothing in Collenette's study (1934) in Brazil. The usual great inequality itself suggests that some additional, though perhaps minor, nutritional requirement is obtained, since it is unlikely that water would be required in very different quantity in the two sexes.

The habit of probing at contaminated soil and decaying animal refuse is known throughout the Rhopalocera. The families Papilionidae and Satyridae, lacking, presumably by chance, from my own observations, are mentioned on many occasions by Norris, and latterly by Payne & King (1969). The Riodinidae were mentioned by Bates (1863). Several authors have noted a few day-flying Pyralidae, Geometridae or Thyrididae along with the butterflies, but only Collenette (1934, Brazil) appears to have observed a substantial night-time fauna comparable to that recorded above. A few records are given also by Payne & King (1969). Outside the Rhopalocera the habit seems to be limited mainly to certain systematic groupings. Pyralidae, Geometridae and Noctuidae are the most frequent, with several observations also of Sphingidae; most of the remaining records refer to families related to one or another of the above (Thyrididae; Uraniidae; Arctiidae, Agaristidae, Notodotidae). The

present records of Tortricidae and Pterophoridae, and the old record of Psychidae quoted by Norris (p. 81), stand rather apart.

The strikingly gregarious habits of many puddle-frequenting butterflies receives considerable attention from Norris; and some fine photographs of dense groups, chiefly in the tropics, are given by Klots (1958). Collenette & Talbot (1928), in experiments with *Catopsilia* involving paper models, have shown that the group is built up by visual recognition of the already established individuals. The gregarious habit is especially conspicuous in Pieridae. In Nymphalidae and Hesperidae, however, a response to odour is highly developed, and the insects tend to respond individually to the feeding sites and often do not form notable aggregations. Many Nymphalidae likewise find their sources of sugar mainly by smell, and tend to feed at ripe fruit rather than at conspicuously coloured flowers.

In discussing the various forms of the habit of feeding at animal excreta and refuse, Norris refers to Shannon's observations (1928) in Argentina that certain moths probe at the secretions and pus around the eyes of mammals. More recently considerable attention has been given to the eye-frequenting moths, in studies in tropical Africa and Asia (Reid, 1954; Büttiker, 1967; Bänziger & Büttiker, 1969). Irritation and pain are caused as the moth probes under the eyelid with its proboscis, and the possibility of transmission of infections has been raised. The ingested material includes lachrymal secretions and pus, and sometimes also blood from accidental sores or wounds. About 30 species of eye-frequenting moths have been recorded. The great majority belong to the Noctuidae, Pyralidae and Geometridae, in somewhat similar numbers; and in addition there are two records of Notodontidae and one of Sphingidae (and one record also of a lycaenid butterfly). Thus the eye-frequenting moths belong to exactly the same array of families as the other excreta feeding forms. The relationship between the two groups is sometimes much closer still. The genus *Arcyophora* (Noctuidae) which includes several of the most important eye moths, includes also a species taken on the carcass of a bullock (Reid, 1954). *Pingasa chlora crenaria* Guen. (Geometridae) is recorded both from the eyes of ungulates (Büttiker, 1967) and from dung and contaminated soil (Bänziger, 1971); the genus *Scopula* contains an eye-frequenting species in Thailand (Büttiker, 1967) and puddle-margin and carrion species in Ontario (above); and *Semiothisa*, again with eye-frequenting species in Thailand, is represented by the very closely related genus *Itame* in the present work. The genus *Pyrausta* figures in Shannon's (1928) list of eye moths in Argentina and



in the present work. Thus Norris is almost certainly correct in making the association.

The sex ratio of the eye-frequenting moths is adequately recorded in only two cases, the noctuids *Arcyophora sylvatica* Büttiker and *Lobocraspis griseifusa* Hampson. In the former, males and females occur in similar numbers, and in the latter females exceed males by about three to one. This is very different from the usual sex-ratio of puddle-margin and dung feeding Lepidoptera, though roughly similar to the particular case of the Noctuidae recorded on sweat-impregnated clothing by Colenette (1934). Colenette's itemized list of the sex-ratios of the various species shows that this habit, in the Noctuidae, requires a much more detailed study. It is clear, however, that the usual preponderance of males at animal excreta is not an absolute phenomenon; it does not indicate a radical difference in the physiology of the two sexes such as is found in the mosquitoes and other bloodsucking Diptera, but a more quantitative difference that might vary with circumstances. Thus the sex-ratios of the eye-frequenting noctuids do not tell seriously against the derivation of the habit from excreta-feeding.

Bänziger (1968, 1971) has found recently that the noctuid, *Calpe eustrigata* Hamps., is a true bloodsucker, able to pierce the skin of mammals with its apically armoured proboscis. Another species of *Calpe*, *C. minuticornis* Guen., is recorded as a eye-moth, and yet another eye-moth, *Mocis undata* Fabr., falls into the same sub-family (Catocalinae) (Büttiker, 1962, 1967). It is very likely therefore that this bloodsucking represents an extreme case of the group of feeding habits under discussion. No information as to sex is given in the work on these insects.

Bänziger, however, suggests that blood-sucking is a derivative of the fruit-piercing habit. Fruit-piercing is well known among this section of the Noctuidae, and many of the moths have an armoured proboscis approaching that of *C. eustrigata* (Hargreaves, 1936; Büttiker, 1962; Bänziger, 1971). The suggested relationship of the two habits appears, nevertheless, to be very improbable. Fruit-piercing, like flower-visiting, provides the insect with sugar; the mud-, dung-, and carrion-visiting habits, from which eye-frequenting and blood-sucking have apparently evolved, provides the insect with nutrients of an entirely different kind. The latter requirement, whatever its nature may be, is typically characteristic of the male sex; and occurs only in certain families, for the most part highly specialized ones and frequently ones in which the sugar-feeding habit is also highly developed (e.g. Rhopalocera, Noctuidae). Indeed, fruit-piercing has been observed in the blood-sucking *Calpe eustrigata* itself (Bänziger, 1968, 1971), in the eye-visiting *C. minuticornis*.

in other species of *Calpe*, and in many other genera of the sub-family. Thus the two types of habit are by no means alternatives, one of which has evolved from the other; rather sugar-feeding is a basic (plesiotypic) habit of the Lepidoptera that has been maintained in the majority of the component groups, while the 'animal excreta' group of habits appears to be a development *sui generis* that exists alongside sugar-feeding in a limited range of forms. (Bänziger is further mistaken in drawing a comparison with the mosquitoes. Here again there are two kinds of feeding habit, sugar feeding and blood sucking; but they exist side by side in many species and are indeed both plesiotypic features of the order Diptera. In no sense are they alternatives one of which has evolved from the other (see Downes, 1958).) There is however only one feeding organ and one mode of food uptake in Lepidoptera; and it would not be unexpected that a modification of the proboscis associated with a change in the manner of taking sugar (from probing at floral nectaries or rotting fruit to piercing the rind of sound fruit) might elicit a change in the other feeding habit also (from absorbing liquid in contaminated mud or dung to probing under the eyelid and finally to piercing the skin). This is what appears to have taken place in *Calpe eustrigata*.

### General Summary

An accessory feeding habit, that of feeding at contaminated liquids and decaying animal material, is found in several groups of Lepidoptera, especially Rhopalocera, Noctuidae, Geometridae and Pyralidae. The habit is usually almost restricted to the male sex. Its significance is not known but it is probably not related to a need for protein and almost certainly not, in essence, a requirement for water; well dried materials can be utilized by repeated salivation. Its most common expression is the habit of feeding at the margins of contaminated puddles, but dung and carrion are preferred if available. In the tropics various noctuids, geometrids and pyralids probe at the exudates of the eyes of mammals, and it seems likely that this is a specialized form of the same habit; it is proposed also that the blood sucking of the noctuid *Calpe eustrigata* is a further specialization of the same nature.

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## A NEW GENUS AND SPECIES OF OECOPHORIDAE FROM TROPICAL AMERICA

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The species described below is so striking, and such an unusual oecophorid, that its presence in the Neotropical fauna should be recorded. It is nearly related to the genus *Filinota* Busck and adds another link in the growing classification of the South American fauna.

The drawings for this paper were made by Mrs. Elsie H. Froeschner, staff artist, and the photograph was produced by Victor Krantz, both of the Smithsonian Institution.



Fig. 1. *Profilinota phillita*, new species: adult male paratype.

### **Profilinota**, new genus

Type species: *Profilinota phillita*, new species (by monotypy and present designation). The generic name is of feminine gender.

Labial palpus very long, slender, recurved, exceeding vertex; third segment slightly longer than second, acute. Maxillary palpus minute, appressed to base of tongue. Head roughened; ocellus absent. Antenna as long as forewing, long ciliated for more than three-fifths its length; scape with pecten. Forewing with 12 veins; 1b furcate; 2 from near outer three-fourths; 3 from angle; 3, 4 and 5 nearly equidistant; 7 and 8 stalked, 7 to termen slightly below apex; 10 nearer to 9 than to 11; 11 from middle; termen very slightly convex. Hind wing with 7 veins; 2 from three-fifths; 3 and 4 coincident, from slightly before angle; 5, 6 and 7 about equidistant. Posterior tibia roughened above with long hairlike scales. Male genitalia with uncus absent; gnathos well developed.

This genus is very closely related to *Filinota* Busck (1911: 206), but differs from it by the separate veins 3 and 4 of the forewing, by having a well developed antennal pecten, the absence of an uncus; and the length of third segment of palpus is longer than second.

Busck says of the antenna of his type "basal joint without pecten." The type, and three additional specimens before me have no pecten, although two examples have a single scale, somewhat out of place, on the scape of one side, that might be considered a weak development of that character. Busck further states "7 to costa" [of forewing]. I would deter-

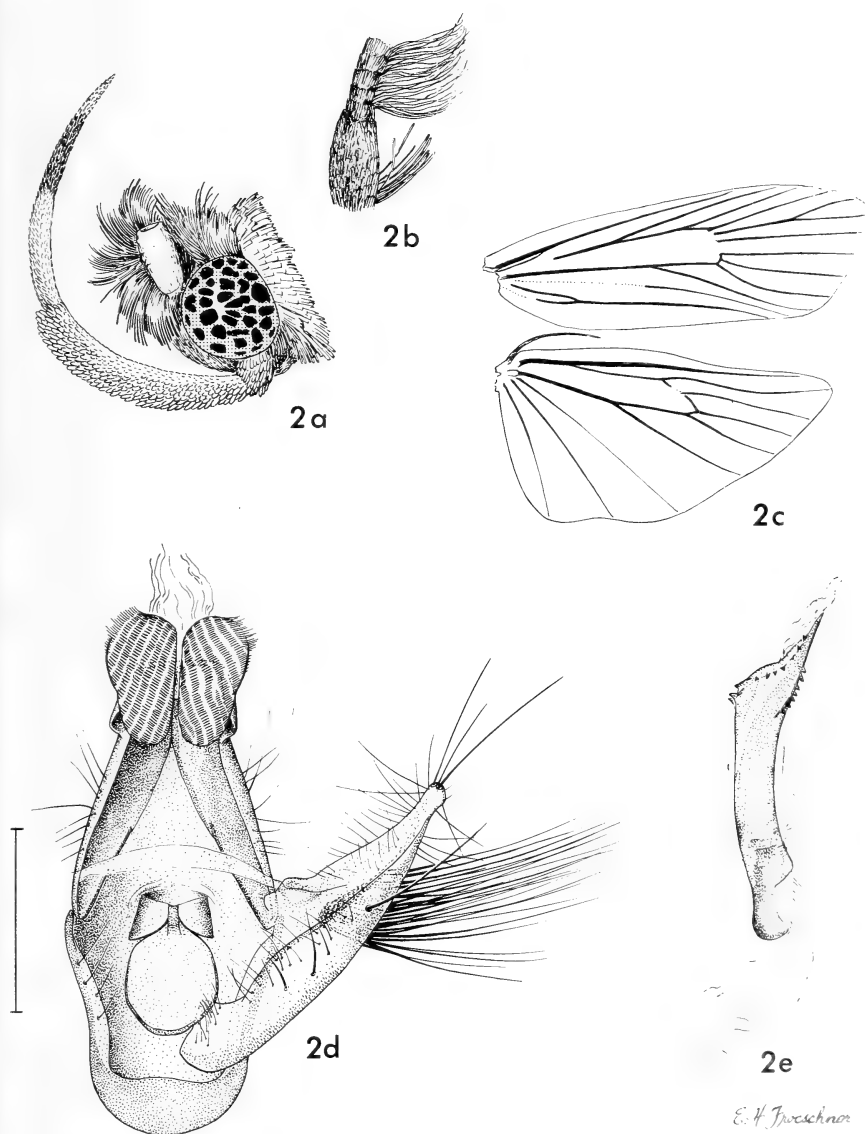


Fig. 2. *Profilinota phillita*, new species: a, lateral aspect of head showing palpus; b, section of antenna showing pecten and ciliations; c, venation of right wings; d, ventral view of male genitalia with left harpe and aedeagus omitted (scale shown equals 1 mm.); e, aedeagus.

E. H. Jeschke

mine the position of vein 7 as at apex. Vein 7 of *Profilinota* extends to termen just below apex.

Meyrick (1922: 158) redescribed *Filinota*, apparently from a combination of characters of several species. He stated "ocelli posterior" but they are absent from the type species. He also gave a rather startling array of venational characters, but these various combinations are suspect as far as the generic limits of *Filinota* are concerned.

### ***Profilinota phillita* Clarke, new species**

Figs. 1-2

**Alar expanse** 32-34 mm. **Labial palpus** buffy brown; second segment olive brown on outer side at apex; third segment olive brown beyond basal third; apex light buff. **Antenna** olive brown shading to buffy brown apically. **Head** sordid white on crown and vertex; face buffy brown; lateral tufts olive brown. **Thorax** light buff; collar and base of tegula and spot posteriorly olive brown; apex of tegula light buffy brown. **Forewing** ground color buffy brown shading to olive brown dorsally; on dorsal edge two elongate white marks, the first reaching to near middle, the second to tornus; at end of cell a faint olive brown spot; cilia white at tornus, then concolorous with forewing. **Hingwing** basal two-thirds white; outer third buffy brown; cilia white adjacent to white portion of wing, buffy brown beyond; a few white cilia at apex. **Foreleg** pale buffy brown; tibia shaded olive brown on outer side; tarsal segments olive brown on outer side; **midleg** similar; second to fourth tarsal segments buff basally; **hindleg** pale buffy brown; tarsal spurs buff; tarsal segments marked buff on outer side. **Abdomen** buffy brown dorsally, ocherous white ventrally.

**Male genitalia** (slides JFGC 12252, 12253): Harpe elongate, triangular, broad basally, tapering to a bluntly pointed cucullus; on outer side of harpe, about middle, a cluster of long setae. Gnathos large, consisting of two spined lobes. Uncus absent. Vinculum rounded, thickened medially. Tegumen about as long as harpe, truncated posteriorly. Anellus an oval plate with a sclerotized circular band posteriorly. Aedeagus stout, slightly curved, pointed and armed with two sets of teeth, one ventrally, one apically; vesica unarmed.

**Holotype**: U. S. National Museum No. 72172.

**Type locality**: Venezuela, Aragua, Rancho Grande, 1100 m.

**Distribution**: Venezuela, Peru.

**Food plant**: Unknown.

Described from the holotype male (31 October 66, S. S. and W. D. Duckworth) and one male paratype (Peru, R. Huacamayo, Carabaya, dry s., 3100 ft., June 04, G. Ockenden). Female unknown. Paratype in the British Museum (Natural History).

There is no described species, except the type species of *Filinota*, *F. hermosella* Busck, with which this striking moth can be compared structurally. This brown and white species presents a great contrast to the red, yellow and white *hermosella*, but reminds one of an oversized *Hastamea argentidorsella* Busck, from which it is abundantly distinct structurally.

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RECORD AND ILLUSTRATION OF SOME INTERESTING  
MOTHS FLYING IN TEXAS (SPHINGIDAE, CTENUCHIDAE,  
NOCTUIDAE, NOTODONTIDAE, GEOMETRIDAE,  
PYRALIDAE, COSSIDAE)

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This paper illustrates and records the presence in Texas of some moths which are considered interesting because they are either rare, or not included in the McDunnough check list. Some of them are probably new records for the United States.

SPHINGIDAE

*Amplypterus donysa* (Druce). Fig. 1.

Ann. Mag. Nat. Hist., Ser. 6, 4: 78, 1889.

Big Bend Nat. Park, Green Gulch, 3 May 1972, 1 ♂; 6 May 1972, 1 ♀; 12 May 1972, 1 ♀. The male is rubbed but the females are very nice, and it seems probable that Green Gulch or some other place nearby was the breeding area. Dr. J. G. Franclemont who was with us when we discovered these insects in our traps says (in litt.) "... from what little is known about the host plants of the group, I judge that larva feeds on some member of the Anacardiaceae, possibly *Rhus microphylla* or *R. triloba*." Both of these were growing where the moth was taken. The forewings are different shades of ashy green, the hindwings mostly of the color of crushed strawberries.

CTENUCHIDAE

*Syntomeida melanthus* (Cramer). Fig. 2.

Pap. Exot. 3: 94, 175 (index); pl. 248, fig. c, 1779.

Big Bend Nat. Park, 21 specimens, all taken in the desert around the Chisos Mountains, from early April to late June, and from late August to early October. The wings are bluish black with yellowish-white spots.

*Episcepsis inornata* Walker. Fig. 3.

List Lep. Ins. Coll. Brit. Mus. 7: 1636, 1856.

Santa Ana National Wildlife Refuge, 14 November 1971, 2 ♀♀. The specimen pictured is badly rubbed. The wings are powdery black. The abdomen is sprinkled with shining steel-blue scales.

NOCTUIDAE

*Euxoa xasta* Barnes & McDunnough. Fig. 4.

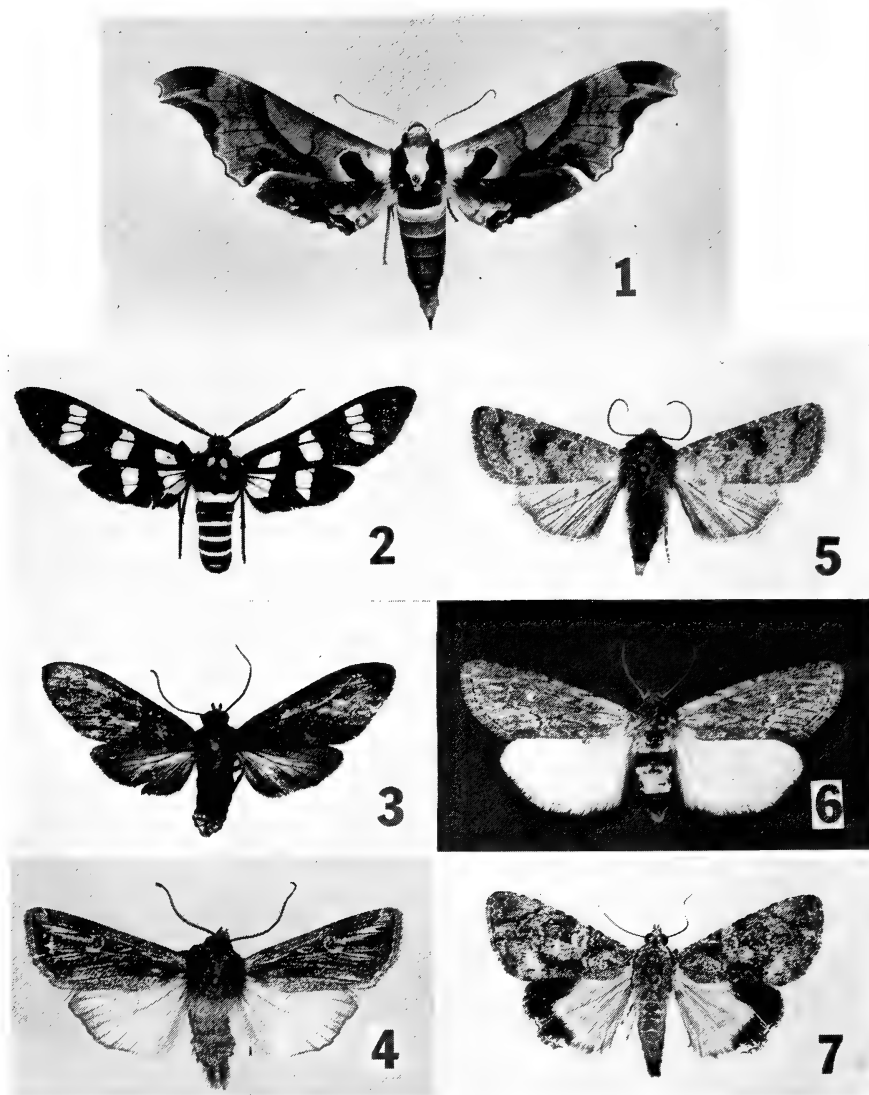
Can. Entomol. 42: 429, 1910.

The rarity of this Agrotinae is my reason for giving my record of captures, although it is included in McDunnough's check list and Kerrville, Texas is the type locality. Fort Davis, 17 May 1966, 1 ♂; 18 May 1971, 1 ♂. Big Bend National Park, Government Spring, 27 March 1971, 1 ♂; 6 May 1972, 1 ♂, 3 ♀♀. Sierra Diablo Wildlife Management Area, 14 July 1971, 1 ♀.

*Eriopyga mulina* Schaus. Fig. 5.

Trans. Amer. Entomol. Soc. 21: 237, 1894.

Big Bend National Park, where trees and brush are growing: Green Gulch, Oak



Figs. 1-7. 1, *Amplifypterus donysa* (Druce) ♀, Big Bend Nat. Pk., Green Gulch, 6 May 1972; 107 mm. 2, *Syntomeida melanthus* (Cram.) ♂, Big Bend Nat. Pk., Chihuahua Desert near Nugent Mt., 17 Sept. 1971; 45 mm. 3, *Episcepsis inornata* Wlk. ♀, Santa Ana Nat. Wildl. Ref., 14 Nov. 1971; 32 mm. 4, *Euxoa xasta* B. and Mc.D. ♂, Big Bend Nat. Pk. Government Spring, 27 March 1971; 36 mm. 5, *Eriopyga mulina* Schaus ♀, Big Bend Nat. Pk., Green Gulch, 4 October 1967; 34 mm. 6, *Emariannia cucullidea* Benj. ♂, Sierra Diablo Wildl. Mgt. Area, 1 Sept. 1970; 36 mm. 7, *Neophanis respondens* Wlk. ♀, Brownsville, 7 Nov. 1969; 42 mm.



Spring, Government Spring; 13 specimens, one in March, one in May, the others from late September to late October. Forewings different shades of lustrous brown, hindwings more dusky.

*Emariannia cucullidea* Benjamin. Fig. 6.

Pan Pac. Entomol. 9: 3, 1933.

Alpine, 17 Sept. 1962, 1 ♀. Fort Davis, 27–29 Aug. 1964, 2 ♂♂, 2 ♀♀; 6 Sept. 1964, 1 ♂; 28–29 Aug. 1970, 2 ♂♂. Sierra Diablo Wildlife Management Area, 15 July 1969, 1 ♂; 1 Sept. 1970, 1 ♂. The forewings are patterned in dusky brown over a lighter brown background. The hindwings are white.

*Neophanis respondens* Walker. Fig. 7.

List Lep. Ins. Coll. Brit. Mus. 15: 1720, 1858.

Brownsville, 7 Nov. 1969, 1 ♀. Forewings patterned in black over mossy green. Hindwings shiny orange-yellow with black margin.

*Iscadia daemonalis* Dyar. Fig. 8.

Proc. U.S. Nat. Mus. 38: 258, 1910.

Big Bend National Park, Green Gulch, 6 Oct. 1966, 1 ♂. Artesia Wells, LaSalle Co., Chaparral Wildlife Management Area, 28 Sept. 1971, 5 ♂♂; 10 Nov. 1971, 2 ♂♂; 12 June 1972, 1 ♂, 1 ♀. Santa Ana National Wildlife Refuge, 14 Nov. 1971, 1 ♀. Forewings dark blackish brown, tipped with gray, crossed with fine, wavy, transverse black lines. Hindwings white, with black margin in the female.

*Meropleon titan* Todd. Fig. 16.

J. Wash. Acad. Sci. 48(1): 27, 1958.

Canadian, 27 September 1968, 3 ♂♂. This collection extends the known distribution of this species far to the west. Forewings dark brown; hindwings lighter.

*Sigela basipunctaria* Walker. Fig. 9.

List Lep. Ins. Coll. Brit. Mus. 23: 785, 1861.

San Antonio, Mountain View Acres (Roy Kendall's Ebony Hill Laboratory), 9 March 1972, 1 ♂. Fishing camp on Guadalupe River, north of New Braunfels, 12 March 1972, 1 ♂. Black dots on whitish background.

*Matigramma psegmapteryx* Dyar. Fig. 17.

Proc. U.S. Nat. Mus. 44: 301, 1913.

Garner State Park, 24 March 1965, 1 ♂, (identified by J. G. Franclemont who prepared slide A.B. 4). The wings are different shades of neutral gray.

*Herminodes stigmaphiles* (Dyar). Fig. 18.

Proc. U.S. Nat. Mus. 47: 386, 1914.

Big Bend National Park, Green Gulch, Basin, and desert near Nugent Mountain, end of September 1971, 3 ♂♂, 3 ♀♀; Green Gulch, early May 1972, 2 ♂♂. The insect is different shades of dusky brown.

*Orthogramma prona* Moeschler. Fig. 10.

Verhandl. d.k.k. zool bot. Ges. Wien 30: 443, 1880.

Welder Wildlife Refuge near Sinton, 14 November 1968, 1 ♂. The dark areas are dusky brown, the lighter areas yellowish.

*Gonodonta sinaldus* Guénée. Fig. 11.

Spec. Gen. Lepid. 6: 372, 1852.

Santa Ana National Wildlife Refuge and Brownsville, late October to early November, twelve specimens. The dark areas of the forewings are deep chocolate brown, the light areas purplish powdery gray. The hindwings are orange-yellow with a gray border.

I have also a battered specimen of *Gonodonta sicheas* Cramer, taken at Garner State Park, 17 September 1961. It might have been a good specimen when it came.



Figs. 8-15. **8**, *Iscadia daemonalis* Dyar ♂, Artesia Wells, 28 Sept. 1971; 48 mm. **9**, *Sigela basipunctaria* Wlk. ♂, New Braunfels, 12 March 1972; 11.5 mm. **10**, *Orthogramma prona* Moesch. ♂, Welder Wildl. Ref., 14 Nov. 1968; 42 mm. **11**, *Gonodonta sinaldus* Gn. ♂, Santa Ana Nat. Wildl. Ref., 13 Oct. 1971; 35 mm. **12**, *Rhescipha servia* Cram. ♂, Welder Wildl. Ref., 16 Nov. 1966; 38 mm. **13**, *Glymipis concors* Hbn. ♂, Brownsville, 5 Nov. 1969; 23 mm. **14**, *Radara anartoides* Wlk. ♂, Welder Wildl. Ref., 20 March 1969; 27 mm. **15**, *Pentobesa valta* Schaus ♂, Santa Ana Nat. Wildl. Ref., 7 April 1972; 36 mm.

but I overlooked it when I folded the sheet on which I had been collecting, and discovered it only the next morning.

*Rhescipha servia* Cramer. Fig. 12.

Pap. Exot. 4: 66; pl. 321, fig. e, 1782.

This insect with odd looking palps and oddly shaped wings, included in McDunnough's check list as *R. obtusa* Walker, is relatively rarer in collections than in nature. Of 34 specimens in my collection, 23 were taken in the Welder Wildlife Refuge and 8 in the Santa Ana National Refuge; two were taken in February, one in March, two in April, one in May, all the rest in October and November. The record of the other three is as follows: San Antonio, Ebony Hill Laboratory, 9 Sept. 1971, 1 ♀; Guadalupe River near New Braunfels, 12 March 1972, 1 ♂; Artesia Wells, LaSalle Co., Chaparral Wildlife Management Area, 11 June 1972, 1 ♀. The color is brown, more or less dusky, an extremely variable species.

*Radara anartoides* Walker. Fig. 14.

List Lep. Ins. Coll. Brit. Mus. 33: 843, 1865.

Welder Wildlife Refuge, near Sinton, 13 and 14 Nov. 1968, 7 ♂♂; 20 March 1969, 1 ♂. The forewings are different shades of reddish brown, the hindwings orange-yellow.

*Glympis concors* Hubner. Fig. 13.

Zutrag. Samml. exot. Schmett. Zweites Hundert, p. 22, figs. 315-316, 1823.

Of 18 specimens, 15 were taken in the two southernmost counties of Texas, Cameron Co. and Hidalgo Co., all in October and November; the record of the other three is as follows: Houston, 27 Nov. 1964, 1 ♀; Fort Davis, 5 Oct. 1969, 1 ♀; San Antonio, Ebony Hill Laboratory, 9 Sept. 1971, 1 ♂. The wings are brownish gray, patterned with black.

## NOTODONTIDAE

*Pentobesa valta* Schaus. Fig. 15.

Trans. Entomol. Soc. London 49, p. 269, 1901.

Santa Ana National Wildlife Refuge, 7 April 1972, 3 ♂♂. The forewings are pale brownish gray, the hindwings whitish.

## GEOMETRIDAE

*Scordylia atalanta* Guénée. Fig. 19.

Spec. Gen. 10: 383, 1857.

Santa Ana National Wildlife Refuge, 9 April 1966, 1 ♂; 18 November 1966, 2 ♀♀. The wings are egg-yolk yellow and velvety black.

*Aeschropteryx olivata* Warren. Fig. 20.

Nov. Zool. 11: 128, 1904.

Brownsville, 17 specimens taken in April, May, October and November. The insect resembles *Prochaerodes transversata*, but is smaller, more olivaceous, and the wings are shaped differently.

## PYRALIDAE

*Evergestis consimilis* Warren. Fig. 21.

Ann. Mag. Nat. Hist., Ser. 6, 9: 433, 1892.

Davis Mountains, Mount Locke, 27 Aug. 1970, 2 ♂♂; Sierra Diablo Wildlife Management Area, 30 and 31 Aug. 1970, 3 ♂♂, 3 ♀♀. The wings are straw-yellow, blotched with purplish brown.

*Polygrammodes sanguinalis* Druce. Fig. 22.

Biol. Cent. Amer. 2: 218, 1895.

Brownsville, 27 Oct. 1970, 1 ♂. The wings are pale yellow and brownish red.



16



20



17



21



18



22



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23

Figs. 16-23. **16**, *Meropleon titan* Todd ♂, Canadian, 27 Sept. 1968; 40 mm. **17**, *Matigramma psegmapteryx* Dyar ♂, Garner State Pk., 24 March 1965; 31 mm. **18**, *Herminodes stigmaphiles* Dyar ♀, Big Bend Nat. Pk., Chihuahu Desert near Nugent Mt., 21 Sept. 1971; 38 mm. **19**, *Scordylia atalanta* Gn. ♀, Santa Ana Nat. Wildl. Ref., 18 Nov. 1966; 29 mm. **20**, *Aeschropteryx olivata* Warren ♂, Brownsville, 8 May 1967; 40 mm. **21**, *Evergestis consimilis* Warren ♂, Sierra Diablo Wildl. Mgt. Area, 30 Aug. 1970; 25.5 mm. **22**, *Polygrammodes sanguinalis* Druce ♂, Brownsville, 27 Oct. 1970; 29 mm. **23**, *Givira redtenbacheri* Hammerschmidt ♂, Big Bend Nat. Pk., Green Gulch, 28 March 1971; 31 mm.

## COSSIDAE

*Givira redtenbacheri* (Hammerschmidt). Fig. 23.

Naturwissenschaftliche Abhandlungen Haidinger 2: 151, 1847.

Common in Big Bend National Park from late March until early May. It flies sympatrically with *Heterocoma albistriga* B. and McD., which it resembles, although it is a much darker gray. *G. redtenbacheri* is more common in Green Gulch, *H. albistriga* in the Chihuahu Desert.

This random selection of 23 species, chosen among those which have already been described, does not exhaust my reserve of interesting moths flying in Texas. As time permits I intend to carry on with another installment.

## ACKNOWLEDGMENTS

I am deeply indebted to many individuals who generously contributed much time and information, and without whose careful work of identification this paper would not have been possible. To all of the following I express my sincere thanks: Drs. D. C. Ferguson, J. G. Franclemont, D. F. Hardwick, R. W. Hodges, E. G. Munroe, F. H. Rindge and E. L. Todd.

It is a pleasure to acknowledge with thanks the always gratifying cooperation of the administration and managers of the National Parks and Refuges and State owned Wildlife Management Areas.

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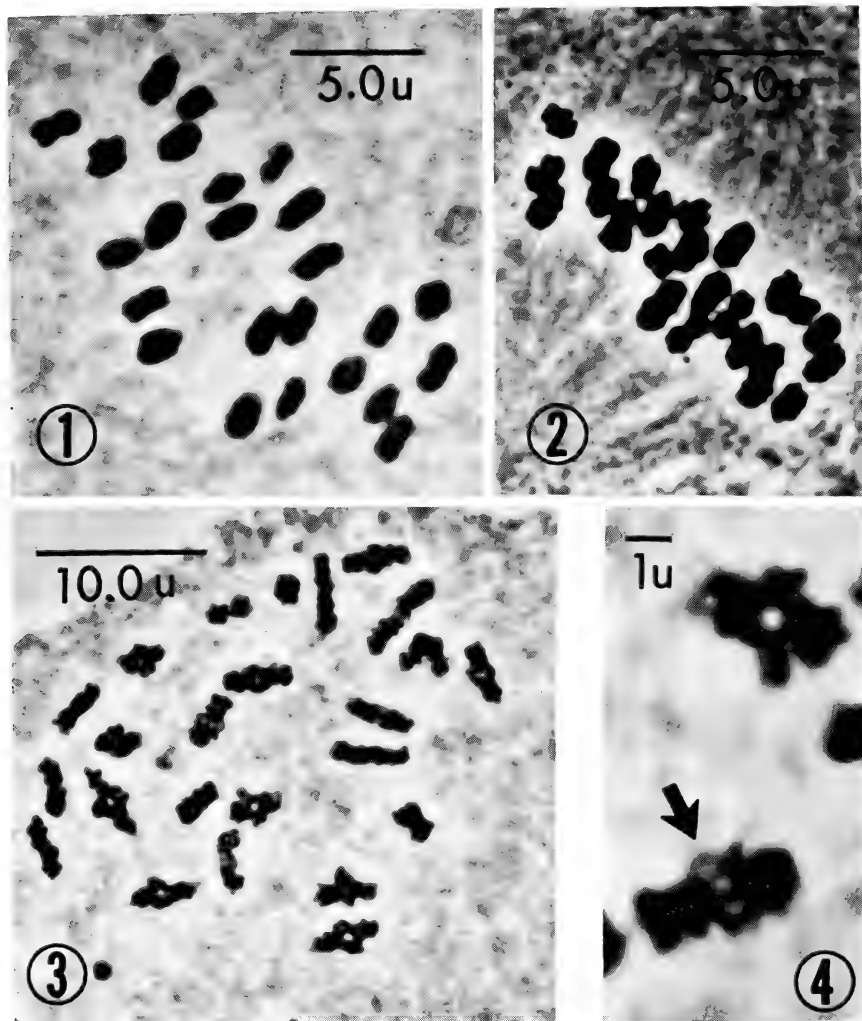
CHROMOSOME NUMBERS FOR *PLEBEJUS* (*ICARICIA*) *ACMON*,  
*P. LUPINI*, AND *P. NEURONA* (*LYCAENIDAE*)

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The *Plebejus acmon* (Westwood & Hewitson) group is comprised of one easily recognized species, *P. neurona* (Skinner), and two closely related, less distinct entities, *P. acmon* and *P. lupini* (Boisduval). The present paper is a report of the results of cytological examinations of certain populations of these species.

Chromosome complements of one population of *P. neurona*, two of *P. acmon*, and three of *P. lupini* from southern and central California have been examined. Field collected adults and laboratory reared pupae were used in this study. Specimens fixed in the field were treated and subsequently examined following the procedure of Emmel (1968).



Figs. 1-4. Chromosomes of the *Plebejus acmon* group: 1, *P. lupini lupini*,  $N = 24$ , metaphase; 2, *P. neurona*,  $N = 24$ , metaphase; 3, *P. acmon acmon*,  $N = 24$ , late diakinesis; 4, *P. acmon acmon*, bivalents from a cell in diakinesis stage, upper bivalent showing probably one nonterminalized chiasma, lower showing terminalized chiasma (note four strands at arrow). All cells primary spermatocytes from laboratory reared pupae, 0.5% lacto-acetoorcein, phase contrast.

Laboratory reared material was treated as follows: tests were removed from pupae one day prior to time of adult eclosion; dissections were carried out in Hayes saline (Hayes, 1953), transferred to 1% sodium citrate for 20 minutes, fixed 5 minutes in 3:1 absolute ethanol:glacial

acetic acid, and stained in 0.5% lacto-acetoorcein (Breland, 1961). Temporary squash preparations were made using thumb pressure.

Slides were examined under oil using phase contrast illumination at a magnification of 960 $\times$ . Photographs were taken on Kodak High Contrast Copy 35 mm film at a film plane magnification of 400 $\times$ .

*Plebejus neurona*.  $N = 24$ . Counts were made in 40 well spread nuclei in meiotic metaphase and two in diakinesis from four individuals from Chuchupate Ranger Station, Ventura Co., California.

*Plebejus acmon acmon*.  $N = 24$ . Counts were made in 75 nuclei in meiotic metaphase, nine in diakinesis, and 10 in mitotic metaphase from eight individuals from Putah Creek, University of California at Davis, Yolo Co., and Monticello Dam, Napa Co., California.

*Plebejus lupini lupini*.  $N = 24$ . Counts were made in 12 meiotic metaphase nuclei from two pupae reared from stock collected at Echo Lake, 8,000 feet, El Dorado Co., California.

*Plebejus lupini monticola*.  $N = 24$ . Counts were made in 31 meiotic metaphase nuclei from six pupae reared from stock collected at La Posta Creek, 3,100 feet, San Diego Co., and Sierra Pelona Road, Mint Canyon, Los Angeles Co., California.

Twenty-four chromosomes were usually counted in primary and secondary spermatocyte metaphase figures from all populations sampled. An occasional cell encountered with more or less than this number was probably due to observation of superimposed or displaced chromosomes within a single cell. Twenty-four bivalents were easily recognized in all cells found in diakinesis (Fig. 3).

Exceptionally favorable diakinesis-diplotene figures were obtained from *P. acmon* and *P. neurona*. At least one chiasma was usually distinguishable in all bivalents at diakinesis and individual chromatids were sometimes resolved in bivalents where chiasmata had terminalized (Fig. 4, arrow).

A haploid chromosome number of  $N = 24$  conforms to that previously reported for one other member of the subgenus *Icarica*; *Plebejus icarioides* (Boisduval) (Maeki & Remington, 1960). Although cytologically detectable chromosomal differentiation has not been found in this group, examinations of populations of the *P. acmon*-*P. lupini* species complex from areas outside of California where intergradation and possible hybridization occurs may be worthwhile.

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*CALLOPHRYS (INCISALIA) POLIOS* (LYCAENIDAE):  
DISTRIBUTION IN NORTH AMERICA AND  
DESCRIPTION OF A NEW SUBSPECIES<sup>1</sup>

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*Callophrys (Incisalia) polios* was described by Cook and Watson in 1907. Subsequently Cook published two papers (1907, 1908) in which he identified the larval foodplant and discussed part of the life history of this insect. The egg is shown in a plate and described in the text of the 1908 paper, but the paper ends at this point with the statement "To be continued." Apparently the proposed continuation was not published. In his 1907 paper, Cook mentioned having reared *polios* to the pupal stage, but did not describe the larva or pupa. A footnote in the same paper mentions that William P. Comstock had reared *polios* from ova to maturity.

Cook and Watson described *polios* from a series of 84 specimens taken at Lakewood, New Jersey. Mention was also made of specimens from Calgary, Alberta, "Graham's Park on Rio de los Pinos, Cal.," and Colorado. These were not included in the type series. Later Cook (1908) corrected the Graham's Park locality to Colorado and indicated that "Cal." was a misprint in the earlier paper.

In the 1908 paper, Cook noted the known distribution of *polios* as New Jersey, Massachusetts, New Hampshire, Maine, Nova Scotia, Indiana,

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<sup>1</sup> Published with the approval of the Director, Wyoming Agricultural Experiment Station, as Journal Article no. JA 533.

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Alberta, and Colorado. He also listed Puget Sound (Washington), based upon Wright (1905).

Since Cook's papers, little has been published on *polios*. The butterfly is listed in a variety of checklists. Brief descriptions are included in regional works (Clark & Clark, 1951; Brown *et al.*, 1957; Shapiro, 1966). Klots (1951) provided additional distribution data for the eastern United States as did Clench for North America (1961). Holland (1931) said little about the insect.

The larval foodplant was identified by Cook as *Arctostaphylos uva-ursi* (L.) Spreng. (Ericaceae). Clench (1961) also suggested *Epigaea repens* in Pennsylvania, as did Shapiro (1966).

In 1968, we undertook a study of *C. polios* in the Rocky Mountain region, and later extended our work to include the distribution of this species in North America. Ferris has attempted several times to rear *polios*, but with little success. The foodplant in Wyoming has been identified as *A. uva-ursi*, but the females appear quite reluctant to oviposit in captivity. Oviposition has been observed at the bases of the flower buds and on the leaves of the hostplant. The ova have been adequately described by Cook (1908). In the west, the first instar larvae are pale green and covered with long fine hairs. To date, we have not succeeded in rearing beyond the first instar.

### Distribution

During the course of this study, hundreds of specimens of *polios* from both museum and private collections were examined. Additional locality data were provided by a number of individuals. It soon became apparent that *polios* could be divided into two subspecies. The nominate subspecies occurs east of the 95th meridian. In the continental United States, the Great Plains appear to form a barrier between the eastern and western populations. To the north, a blend-zone occurs in Manitoba. We have reliable records of nominate *polios* from Nova Scotia, Quebec, Ontario, Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Virginia, West Virginia, Indiana, Illinois, Michigan, Wisconsin, and eastern Minnesota. As yet, we have no records from New Brunswick, Vermont, Delaware, Maryland, and Ohio, although one might expect the butterfly to occur in the mountainous areas of western Maryland, and it undoubtedly occurs in Vermont. The foodplant is rather scarce in Ohio.

The western subspecies, which is described below as a new subspecies, occurs in Arizona, New Mexico, Utah, Colorado, Wyoming, western South Dakota, Idaho, Montana, Oregon, Washington, Manitoba, Saskatchewan,



Fig. 1. Distribution of *Callophrys polios* in North America. Cross-hatched area in Manitoba indicates a blend-zone between the eastern and western subspecies. Solid dots indicate states, provinces, and areas from which collection records exist.

Alberta, British Columbia, Northwest Territory (District of Mackenzie), Yukon Territory, and Alaska. Until recently, there were no records from Montana, although the specimens listed by Elrod (1906) as *irus* (Godart) are probably *polios*, or possibly *fotis schryveri* Cross. Cook (1908) mentioned confusion among various authorities over *polios*, *irus*, and *henrici* (Grote & Robinson). In 1971, S. Kohler found both *polios* and *fotis schryveri* in Missoula Co., Montana. The occurrence of *polios* in North Dakota appears doubtful. Occasional references to the occurrence of *polios* in California probably relate to the misprint in the Cook and Watson paper, or to confusion of *polios* with *fotis* (Strecker).

Fig. 1 illustrates the presently known distribution of *C. polios* in North America. Exact locality citations are too numerous to include. The insect does not occur in the total area delineated, but is restricted to those areas within the boundary where the foodplant grows. In the west, this is generally in foothills regions; in the east, at the edges of woods and in boggy areas near the hostplant. There are certain areas where the foodplant occurs, but from which *polios* has not yet been collected. These are noted in the figure by the hatched areas. Within the overall area denoted for *polios*, various isolates occur and certain of these are noted by the inner closed lines in Fig. 1. Some of the areas between isolates appear to be unsuited to *polios*. The principal isolates encompass the following regions: northeast coastal area; Virginia-West Virginia; Illinois-Indiana; Black Hills, South Dakota; Utah; Arizona; and southern Michigan. It would appear, from Kohler's recent discovery, that *polios* has probably been overlooked in many areas in the Rocky Mountains and may be much more widely distributed in this region than present records indicate.

***Callophrys (Incisalia) polios obscurus*, Ferris and Fisher,  
new subspecies**

The new subspecies differs from *C. p. polios* in two consistent characters. The dorsal color in both sexes is uniformly a distinct gray brown rather than the warm rufous brown of the eastern subspecies. The scent pad on the forewing of the males of *obscurus* is black, or darker than the ground color. In *polios*, the scent pad is generally pale, or lighter than the ground color, although there are individual exceptions in both subspecies. The maculation of the undersides in both subspecies is highly variable, and we could find no consistent characters which allow separation of *obscurus* from *polios*. Generally speaking, the hoary patches on the secondaries are brighter and more clearly defined in *obscurus* than in *polios*, and the other markings are more crisply defined. Fresh specimens should be used for comparison as fading occurs rather rapidly under exposure to strong light or elevated temperature.

**Variation:** The occurrence of fulvous markings in the anal area of the DHW is infrequent in males from Colorado and Wyoming. This coloring is occasionally observed in females from Colorado and Wyoming, and fulvous markings are common in both sexes of *polios* from New Jersey. Some specimens from northern Idaho exhibit about as much ruddy color as eastern *polios*, but the males have the dark scent pads of *obscurus*. Specimens from Michigan have well pronounced fulvous areas over the outer two-thirds of the DHW in a majority of the specimens examined. Some have this character on the FW as well, giving these specimens a somewhat bright appearance. Fewer Michigan specimens are dark as in New Jersey material. Ventrally, Michigan specimens tend to be lighter than either eastern or western populations.

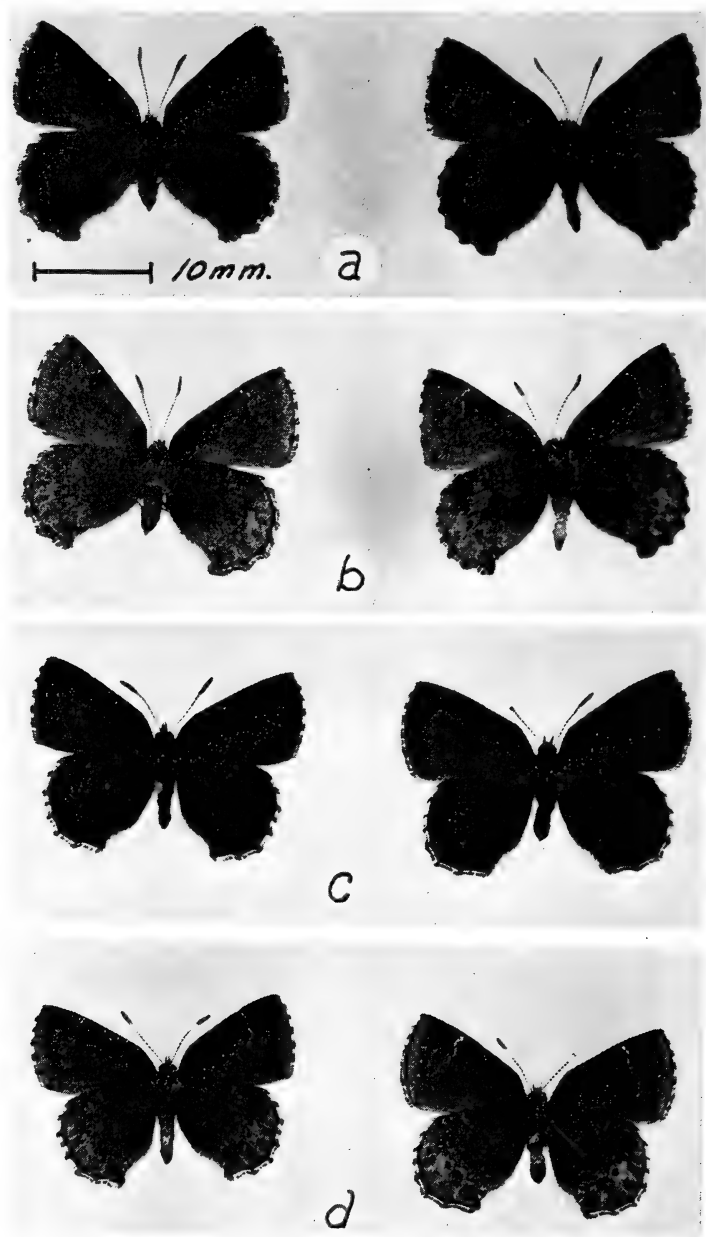


Fig. 2. *Callophrys polios obscurus* Ferris and Fisher: a. holotype ♂ (right) and allotype ♀ (left); b. same, undersides; c. specimens from Goldstream Valley, Alaska (male at left); d. same, undersides.

and the maculation appears to be somewhat frosted in aspect, producing a much less clearcut maculation than is found in specimens from other areas. This is also true, to some extent, of specimens from central Maine. Ontario specimens also have characters as described for the Michigan area, but somewhat less pronounced, which gives Ontario material a darker aspect, but not so dark as New Jersey *polios*, which is still lighter than western *obscurus*.

Specimens from Maine are generally lighter in color than New Jersey material. Manitoba specimens, especially from Sandilands Provincial Forest, are rather dark. The fulvous areas are not pronounced, but the scent pads are pale as in eastern *polios*. Some populations from eastern Manitoba may be referred to *polios* and some from western Manitoba to *obscurus*, but in the broad sense, Manitoba represents a blend-zone region. Alaskan specimens tend to be a warmer brown than *obscurus* from Colorado and Wyoming. Pale scent pads occur more frequently than in other western populations. They are closer to Maine specimens than any other of the western material. A similar situation occurs with *C. augustinus* (Westwood) from Alaska.

**Holotype male.** The holotype was collected on Lookout Mountain, Jefferson Co., Colorado. The male holotype bears a red label, machine printed in black ink: *C. polios obscurus*/ Ferris & Fisher/HOLOTYPE ♂; and a white data label, machine printed in black ink with handwritten date: Lookout Mt., Jefferson Co., COLO./above Golden 6500-7200 ft./leg. Mike Fisher/14 May 68.

**Allotype female.** The female allotype bears a green label, machine printed in black ink: *C. polios obscurus*/Ferris & Fisher/ALLOTYPE ♀, and a data label similar to that of the holotype with the date 12 May 68.

The forewing length of both the holotype and allotype is 12.5 mm. There is remarkably little size variation in the type series.

**Type series.** The new subspecies is being described from a series of 168 specimens, including the holotype and allotype, from the following areas: **Colorado**, 86 specimens from Boulder, Clear Creek, El Paso, Jefferson, and Park Counties, 14 May-2 June 1957, 1960-61, 1967-71, leg. J. D. Eff, M. S. Fisher, R. J. Jae, J. Scott; **Wyoming**, 82 specimens from Pole Mountain, Medicine Bow National Forest, Albany Co., 14 May-6 June 1969-71, leg. C. D. Ferris and M. S. Fisher.

The holotype and allotype are deposited in the collection of the Los Angeles County Museum of Natural History. Paratypes are being distributed to the following museum collections: Allyn Museum of Entomology, American Museum of Natural History, Canadian National Collection, Carnegie Museum, Los Angeles County Museum of Natural History, United States National Museum, Michigan State University, University of Wyoming.

Included under the taxon *obscurus* are specimens from Washington. There is some indication (D. Frechin, Seattle, Washington, pers. comm.) that F. H. Chermock had intended to name the *polios* population from the vicinity of Tenino, Thurston Co., but we can find no record in the literature.

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The authors wish to express their appreciation to the following individuals for supplying collection data and the loan of specimens for study: Mr. R. Bailowitz, Portland, Ore.; Mr. W. A. Bergman, Chicago, Ill.; Mr. H. K. Clench, Carnegie Museum, Pittsburgh, Penn.; Mr. P. J. Conway, Chicago, Ill.; Dr. J. P. Donahue, Los Angeles County Museum of Natural History, Los Angeles, Calif.; Mr. J. D. Eff, Boulder, Colo.; Mr. J. H. Fales, USDA, Beltsville, Md.; Mr. W. D. Field, United States National Museum, Washington, D.C.; Mr. R. W. Fischer, Michigan

State University, East Lansing, Mich.; Mr. D. Frechin, Seattle, Wash.; Mr. L. P. Grey, Enfield, Maine; Mr. H. Hensel, Edmundston, New Brunswick; Mr. J. R. Heitzman, Independence, Mo.; Mr. R. L. Huber, St. Paul, Minn.; Mr. R. J. Jae, Denver, Colo.; Mr. S. Kohler, Missoula, Mont.; Mr. I. Leeuw, Cary, Ill.; Mr. G. Lewis, Canadian National Collection, Ottawa; Mr. L. L. Martin, Prescott, Arizona; Mr. B. Mather, Clinton, Miss.; Mr. M. C. Nielsen, Lansing, Mich.; Dr. K. W. Philip, Fairbanks, Alaska; Dr. F. H. Rindge, American Museum of Natural History, New York, N.Y.; Mr. A. C. Sheppard, Lyman Entomological Museum, Ste. Anne de Bellevue, Quebec; Mr. J. T. Sorensen, Cedar Falls, Iowa; Mr. G. D. Willis, Wilmington, Del.; and Mr. B. Wright, Nova Scotia Museum, Halifax, Nova Scotia.

Mr. Harry K. Clench most kindly read and commented upon a preliminary draft of the manuscript and provided considerable distribution data which are incorporated into Fig. 1.

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THE LARVA OF *LOXAGROTIS KYUNE* (BARNES) (NOCTUIDAE)

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*Loxagrotis kyune* (Barnes) was described on the basis of a single female collected in the Huachuca Mountains, Arizona (Barnes, 1904). Barnes originally placed *kyune* in the genus *Hadena*. Except for changes in generic reassignments of the species, no additional published information is available. The following notes constitute the first information about the larval instars of *kyune*.

Dr. John G. Franclemont captured a female moth of *kyune* on the night of 12 July 1967, at Onion Saddle, 7600 feet, Chiricahua Mountains, Cochise County, Arizona. Eggs obtained from the specimen the same night hatched on 19 July. The larvae subsequently passed through five instars before burrowing into the peat moss and sand filled rearing boxes during prepupal activity.

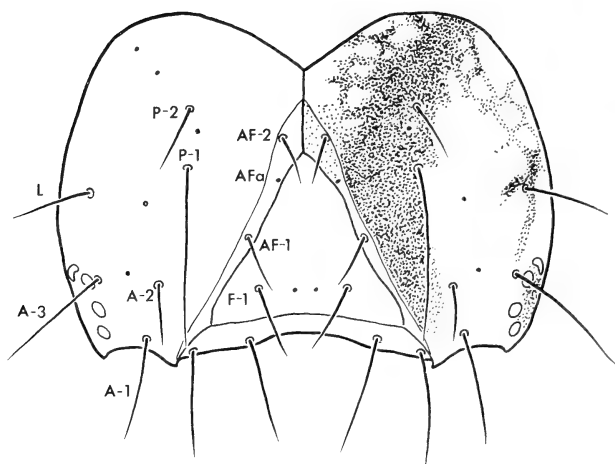
The natural host is unknown. Newly hatched larvae were confined with cuttings of commercial lettuce (*Lactuca* sp.), *Astragalus* sp., *Rubus* sp., *Quercus* spp., *Brickellia* sp., *Viguiera multiflora* (Nutt.) Blake, and *Pseudotsuga douglasi* Carr. (Douglas fir). Except for the last plant, all cuttings showed some feeding signs by the first instars. The greatest feeding was on *Viguiera multiflora*. The second instars fed only on *V. multiflora*, and I eventually discontinued offering the other plants.

The illustrations that accompany the following description of the last larval instar were drawn to scale by a grid system. All scale lines represent 0.5 mm. The terminology and abbreviations follow those adopted earlier (Godfrey, 1972).

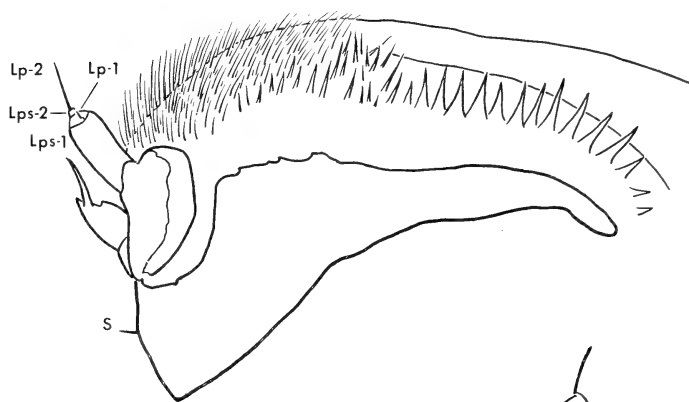
**General.** Head 3.0–3.2 mm wide. Total length 38–43 mm. Abdominal prolegs present on third through sixth segments. Head and body smooth. Dorsal abdominal setae simple; setal insertions minute. Dorsal setae on seventh and eighth abdominal segments 0.75–0.88 times height of seventh abdominal spiracle.

**Head** (Fig. 1). Epicranial suture 0.51 times height of frons. Distance from frontal seta (F-1) to frontoclypeal suture 0.33 times distance between F-1's. Anterior setae (A 1–3) forming slightly less than 90° angle. Adfrontal puncture (AFa) anterior and second adfrontal seta (AF-2) posterior to apex of frons. First posterior setae (P-1's) slightly anterior to apex of frons. Lateral setae (L's) transversely anterior to AFa's. Ocellar interspaces between Oc-1–Oc-2 0.50 times that of Oc-2–Oc-3; Oc-2–Oc-3 4.0 times that of Oc-3–Oc-4.

**Mouthparts.** Oral surface of labrum unspined. Hypopharyngeal complex (Fig. 2): spinneret with distal lip bearing long fringes, short, not surpassing first segment of labial palpus (Lps-1); stipular seta (S) about 0.25 length of Lps-1, twice length of seta (Lp-1) borne by Lps-1 and second segment of labial palpus (Lps-2), about 0.33 length of seta (Lp-2) borne by Lps-2; Lp-1 positioned laterad of Lps-2; distal



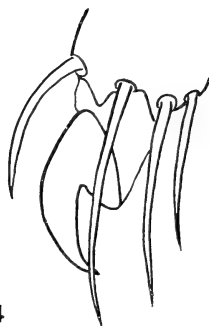
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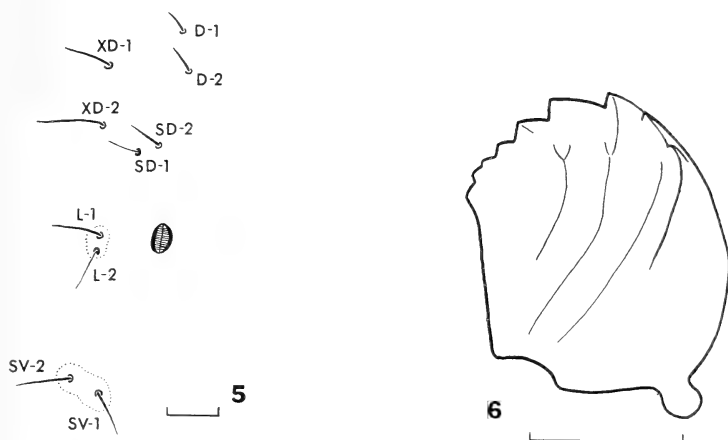
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Figs. 1-4. *Loxagrotis kyune*, Chiricahua Mts., Arizona: 1. frontal aspect of head capsule; 2. left aspect of hypopharyngeal complex; 3. ventral setal arrangement of first abdominal segment; 4. posterior aspect of tarsal claw.





Figs. 5-6. *Loxagrotis kyune*, Chiricahua Mts., Arizona: **5**, left dorsolateral setal arrangement of prothorax; **6**, oral aspect of left mandible.

region of hypopharynx densely covered with fine spines becoming stouter proximad; proximomedial region without spines; proximolateral region bearing single row of about 15 distinct spines. Mandible (Fig. 6): inner ridges distinct; no inner tooth; outer teeth 1-5 forming distinct angles; sixth outer tooth low, divided into smaller subteeth.

**Thoracic segments.** Segment T-1: seta D-2 posterior of line formed by D-1 and XD-2 (Fig. 5); major axis of prothoracic spiracle passing through base of D-2 and distinctly posterior of subventral setae (SV 1-2); SD-1 transversely anterior of D-1 and D-2. Lateral setae (L 1-2) and SV 1-2 enclosed by pinacula. Segments T 2-3: seta L-1 located above and slightly posterior of L-2. Tarsal claw (Fig. 4) with reduced basal angle; tarsal setae simple, tapering distad.

**Abdominal segments.** Ab-1 (Fig. 3): only two subventral setae (SV-1, SV-3) present; SV-1 laterad of line formed by setae V and SV-3. Ab-2-6: three subventral setae present. Ab-8: only one seta in each subventral group. Ab-9: seta SD-1 much finer than setae D 1-2. Anal and subanal setae subequal to lateral setae on anal proleg. Crochets: uniordinal, 18-22 per third abdominal proleg, 22-26 per fourth, 24-28 per fifth, 25-32 per sixth.

**Coloration.** Head pale brown with darker brown freckles. General body color brownish green. Middorsal and subdorsal lines, thin, whitish. Subdorsal area dark olive green with thin white line passing length of body. Lateral area diffusely white with indistinct brown center stripe, passing to tip of anal proleg. Spiracles black.

**Material examined.** 10 specimens, Onion Saddle, 7600 ft., Chiricahua Mountains, Cochise County, Arizona, July-August 1967, from ova of female collected and determined by J. G. Franclemont, reared by G. L. Godfrey. Hypopharyngeal complex on slide G-0203.

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### METHODS FOR EXTERNALLY SEXING MATURE LARVAE AND PUPAE OF *LIMENITIS* (NYMPHALIDAE)

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Little published information exists regarding accurate methods for sexing the larvae and pupae of butterflies. It is well-known, however, that larger larvae and pupae within a brood generally develop into females, whereas, the smaller ones usually turn out to be males. In addition, the majority of males often will eclose at the beginning of a brood, whereas, the latter portion of the brood will consist almost exclusively of females. Nevertheless, numerous exceptions occur, and such methods cannot be considered to be very accurate.

Among the larger moths (Saturnidae and Sphingidae), morphological differences such as the relative breadth of the pupal antennae and subtle differences in the ventral genital plates of pupae have been used for predicting the sex of the imago (Villiard, 1969), and methods for sexing mature larvae of the tobacco hornworm (*Manduca sexta* Johanssen) are known (W. Bowers, personal communication). Recently, other methods have been reported for sexing both the larvae and pupae of the codling moth, *Laspeyresia pomonella* L. (MacLellan, 1972).

During laboratory hybridization studies on the Nearctic *Limenitis*, which were initiated in 1966 and are still in progress (Platt, 1969; Platt, Frearson & Graves, 1970; Platt & Greenfield, 1971), it became apparent that in inter-specific hybrid crosses, either excessive or complete heterogametic (female) inviability often occurs (Haldane, 1922; Remington,

1958). Since egg hatching within hybrid broods sometimes exceeds 50%, it was at once apparent that some female hybrid larvae were initially viable, but then died at certain stages during development. The need for positively determining the sexes of dying hybrid larvae and malformed pupae prompted this study.

The purposes of this paper are to report means for positively sexing the mature larvae and pupae of North American *Limenitis*, and to point out how these and similar methods can add a new dimension to studies of lepidopteran genetics.

### MATERIALS AND METHODS

Larvae of *L. archippus* Cramer and *L. arthemis* Drury were used principally in these studies. The former were collected as over-wintering third instar larvae found in hibernacula during January and February, 1972, and represent stocks collected from Colchester (Chittenden Co.) and Starksboro (Addison Co.), Vermont, as well as a Maryland stock collected from the University of Maryland Baltimore County (Catonsville) campus. The latter species is represented by two broods of over-wintering third instar larvae, which represent  $F_1$  crosses obtained from wild-caught *L. arthemis-astyanax* females collected from the intergrading population at Shutesbury (Franklin Co.), Massachusetts (see Platt & Brower, 1968), and by a third inbred *L. a. astyanax* Fabricius stock obtained several years ago from the Baltimore, Maryland vicinity.

All hibernating larvae were kept in total darkness in a refrigerator within their hibernacula under moist conditions for a minimum of several weeks prior to study. Each hibernaculum then was individually isolated in a labeled plastic-covered styrofoam cup containing leaves of foodplant (*Salix babylonica* L. for *L. archippus* larvae, and *Prunus serotina* Ehrh. for *L. arthemis-astyanax* larvae). The cups were kept in covered transparent shoeboxes containing moist paper towels. The larvae were reared at room temperature in a closed photoperiod chamber under 20 hrs. of fluorescent illumination per 24 hr. day. Mature larvae were permitted to pupate on sticks placed across the tops of the cups.

As each larva emerged from its hibernaculum, it was assigned an individual number. The next day each was sexed independently, using external markings (Fig. 1), which will be described in detail in the results section of this paper. A Wild 3M stereoscope with a Pentax camera back was used for examining and photographing the larvae and pupae. The day following each subsequent larval moult (to the fourth and fifth instars), each larva was again sexed independently, without reference to the previous sexing information. In each instance, the presence or

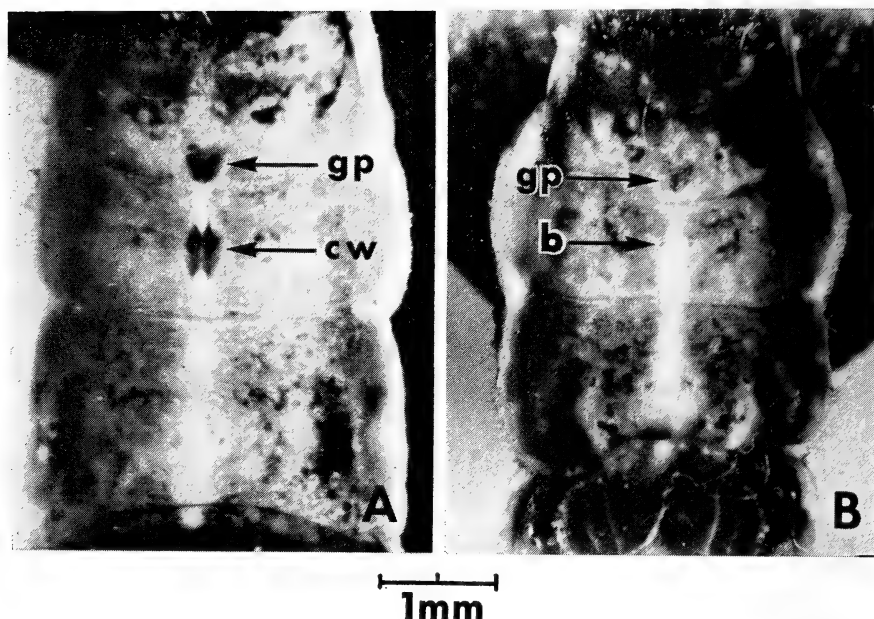


Fig. 1. Morphological sex differences on the ventral surface of the eighth abdominal segment of female (A) and male (B) *Limenitis* larvae. The larvae are oriented with their posterior regions toward the top of the photographs. gp = genital pore; cw = chitin windows of female larva; b = pair of single bristles of male larva.

absence of the same external markings was used to determine the larval sex. Upon metamorphosis, both pupae and adults likewise were sexed independently, using different morphological characters. Fig. 2 shows the morphological traits used for sexing *Limenitis* pupae. All larvae and pupae which died during development were deleted from the data, because the sex of the imago could not be positively determined.

## RESULTS

*External Sex Characters of Larvae.* Third through fifth instar female larvae always possess two small transparent cuticular patches, which we have termed "chitin windows." They are located on the mid-ventral surface of the eighth abdominal segment (Fig. 1A). These transparent spots appear to be dark against the grey-white mid-line, because the green gut of the larva shows through from beneath them. These spots, or chitin windows, lie anterior to a similar bifurcate dark crescentic patch (Figs. 1A, B) located just behind the anterior edge, in the middle of the ventral region of the ninth abdominal segment. The latter spot is

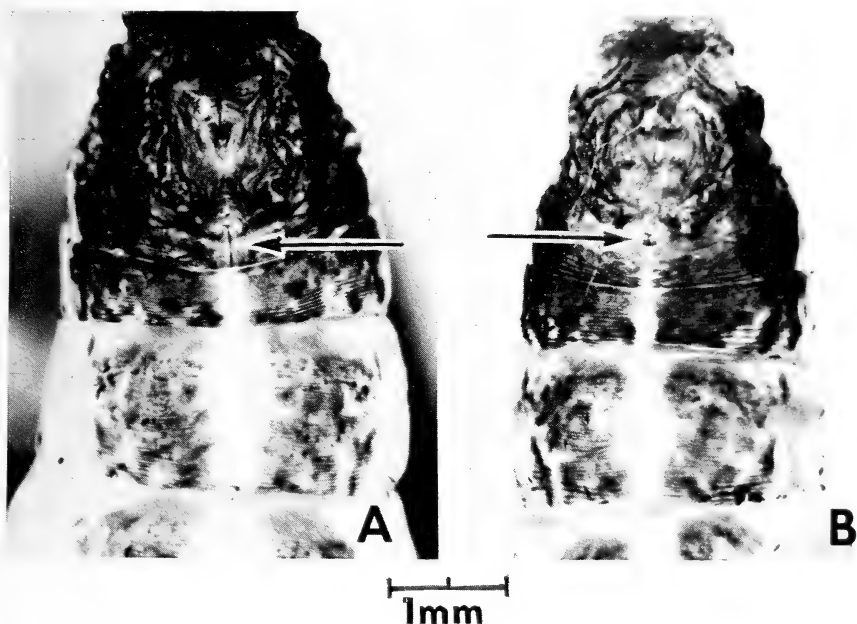


Fig. 2. Morphological sex differences on the ventral genital plates of the eighth and ninth abdominal segments of female (A) and male (B) *Limenitis* pupae. The differences described in the text are indicated by the arrows.

present in larvae of both sexes and apparently marks the primordial genital region. The functions and adult structures (if any) arising from the chitin windows presently are not known, although the female genital structures form in this region of the pupa. Male larvae (Fig. 1B) lack the chitin windows, and so appear to possess an unbroken white mid-line on the ventrum of the eighth abdominal segment. This difference can be determined readily with the naked eye in mature larvae. However, it is best to check all larvae with a stereo-microscope, using low to medium magnification. When this is done, two very small dark bumps, each containing a single short curved bristle, can be seen on the white ventral mid-line of the male larva's eighth abdominal segment. The position of these bumps is comparable to that of the chitin windows of female larvae.

*External Sex Characters of Pupae.* *Limenitis* pupae, likewise, can be sexed externally by examination of the morphology of the genital plates located ventrally, and immediately anterior to the base of the lateral processes of the cremaster. These plates cover the mid-ventral region of the entire eighth, and the anterior margin of the ninth, abdominal segments. Microscopic examination is necessary to observe the male and

TABLE 1. Results of externally sexing *Limenitis* larvae and pupae by independent examination at each stage.

A. Correct sexing observations (percent accuracy given in parentheses):

Species	Numbers			Developmental Stages				
	♂♂	♀♀	Total	Larval instars			Pupae	Adults
				3rd	4th	5th		
<i>L. archippus</i>	32	26	58	41 (71%)	55 (95%)	58 (100%)	58 (100%)	58 (100%)
<i>L. arthemis- astyanax</i> <sup>1</sup>	10	11	21	13 (62%)	16 (76%)	21 (100%)	21 (100%)	21 (100%)
Totals	42	37	79	54 (68%)	71 (90%)	79 (100%)	79 (100%)	79 (100%)

B. Inaccurate sexing observations, given by sex of adult individual (based on a total of 237 observations):

Species	Larval Instars						Grand Totals
	3rd			4th			
	♂♂	♀♀	sub totals	♂♂	♀♀	sub totals	
<i>L. archippus</i>	6	11	17	2	1	3	20
<i>L. arthemis- astyanax</i> <sup>1</sup>	4	4	8	3	2	5	13
Column Totals	10	15	25	5	3	8	33

<sup>1</sup> Includes 3 *L. arthemis arthemis* Drury, 14 *L. arthemis proserpina* Edwards, and 4 *L. arthemis astyanax* Fabricius.

female differences clearly. Female pupae possess a longitudinally slotted mid-ventral pad (Fig. 2A). The slot always extends forward across the eighth segment (where the larval chitin windows were located) to the posterior margin of the seventh abdominal segment, appearing to arise from the segmental fold, at right angles to it. This slotted pad seems to be homologous with the distal ends of the female genital ducts in the imago. Male pupae (Fig. 2B) lack this vertically slotted pad, but possess, instead, two small paired swellings, located posterior to a prominent horizontal fold, which forms the base of a medial flattened isocles triangular plate. This plate is circumscribed by two anterolateral oval plates. This entire small crescentic structure is restricted to the ninth abdominal segment, leaving the mid-ventral region of the eighth abdominal segment intact.

*Accuracy of the Sexing Methods.* The validity of using the external morphological features described above to sex the larvae has been verified in two ways. First, a small number of larvae of both sexes were

dissected, and the developing gonads identified. (In mature larvae of Lepidoptera, the gonads lie beneath the body wall in the dorsal region of the fifth abdominal segment. In *Limenitis*, this region is the central area of the grey-white larval saddlepatch. The developing ovaries of female larvae are paired flattened whitish strands of delicate wavy tissue, often imbedded in fat. The paired reddish-brown oval male testes are somewhat easier to locate in larvae; the latter fuse into a single medial rounded testis in the adult butterfly.) Secondly, 79 larvae of *L. archippus* and *L. arthemis-astyanax* were independently sexed during the third, fourth, and fifth larval instars, and later both as pupae and as adults (Table 1A). External sexing of mature larvae and of pupae was accomplished with an accuracy of 100%. Third and fourth instar larvae were sexed with 68% and 90% accuracy, respectively. Only a total of 33 (14%) inaccurate sexing observations were made in 237 independent larval observations. The majority of erroneous sexings occurred when examining third instar larvae (Table 1B). In most cases, this happened because the chitin windows (which are present) were not clearly visible in the small female larvae.

#### DISCUSSION AND CONCLUSIONS

These methods for externally sexing the fifth instar larvae and the pupae of North American *Limenitis* are 100% reliable. Fourth instar larvae have been sexed with an over-all accuracy of 90%. The methods may be somewhat more reliable for *L. archippus* larvae than for the larvae of *L. arthemis* at this instar (Table 1A). Because of their smaller size (approximately 12 mm long by 3 mm wide, or less), third instar larvae are much more difficult to sex. Our over-all accuracy is only 68% for this stage, with the sexing observations on *L. archippus* larvae again being more reliable than those carried out on larvae of *L. arthemis-astyanax*. We conclude that our methods cannot be considered completely reliable for the third instar. Because of the small size and delicateness of younger larvae, attempts were not made to sex them in the first and second instars.

These larval and pupal sexing methods have been tried on a few larvae of the Western species of Nearctic *Limenitis* (*L. lorquini* Boisduval and *L. weidemeyerii* Edwards). The immature stages of both of these species also can be sexed accurately using these characters. In fact, it is probable that species in closely related genera, such as *Adelpha*, *Apatura*, *Neptis*, *Parthenos*, etc., and, perhaps even more remotely related nymphalines, can be accurately sexed in their immature stages using either these, or similar morphological criteria.

Since sex is a genetically determined trait, the ability to sex larvae and pupae of certain Lepidoptera externally, provides a means of establishing genetic ratios prior to the adult stage. As has been implied earlier in this paper, this becomes a most useful tool in cases involving inter-specific hybridization.

For example, accurate sex ratios now can be established for crosses in which heterogametic inviability occurs during larval growth. Among the species of Nearctic *Limenitis*, inter-specific hybridization occurs only rarely in nature, but can be accomplished readily in the lab by hand-pairing the insects (Remington, 1958; Platt, 1969; Platt & Greenfield, 1971). Although the number of larvae hatching from eggs of such crosses sometimes exceeds 50%, a number of the developing larvae often die prior to, or during pupation. Are these, perhaps, mostly females, since only males are found to emerge from normally formed pupae (especially in hybrid crosses involving the broadly sympatric species, *L. archippus*)?

Preliminary evidence suggests that the answer to this question is *yes*: Recently, 21 hybrid larvae, representing three broods of *L. arthemis-astyanax*  $\times$  *L. archippus* crosses have produced malformed pupae at the end of the fourth instar. Each pupa has been sexed as female externally, and no definite males have been found among them, although it is possible that some of the most malformed ones may represent inter-sex pupae. Several other hybrid larvae have grown slowly to immense size in the fifth instar, but then have failed to metamorphose. Each of these, likewise, has been externally sexed as a female.

Therefore, our methods of externally sexing the immature stages of *Limenitis* provide a means of confirming the developmental stages during which female inviability occurs. Within hybrid female larvae, species incompatibilities in juvenile hormone and ecdysone are implicated, but must be substantiated by further work. Using the external sexing methods to identify female hybrid larvae prior to death, it may be possible to treat them with the appropriate synthetic insect hormones, in order to enable them to pass through a normal metamorphosis. Such techniques may prove exceedingly useful in furthering our present knowledge of evolution among related species of Lepidoptera.

#### SUMMARY

Methods for accurately sexing the fourth and fifth instar larvae and the pupae of the North American species of *Limenitis* by means of external morphological differences are reported. Female larvae possess a pair of prominent dark spots (termed chitin windows) on the ventral white mid-line, located centrally on the eighth abdominal segment; male



larvae lack these spots. Female pupae possess an antero-posterior slotted pad on the ventrum of the eighth abdominal segment, whereas male pupae possess a smaller genital pore, consisting of two bulbous swellings lying just posterior to a prominently horizontal fold, the entire structure being restricted to the ninth abdominal segment. The eighth abdominal segment of male pupae possesses no mid-ventral pad with an antero-posterior slit, as it does in female pupae. These methods proved 100% effective for sexing mature larvae and pupae. Fourth instar larvae were sexed with an accuracy of 90%. However, small third instar larvae could be sexed only with an accuracy of 68%. The genetic implications of being able to externally sex immature stages of *Limenitis*, with respect to inter-specific hybridization studies, are discussed briefly.

#### ACKNOWLEDGMENTS

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ILLUSTRATIONS OF *HELICONIUS* (NYMPHALIDAE):  
SOME RARE AND IMPORTANT SPECIMENS

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Photographed by  
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*Heliconius* butterflies are now being intensively used as research animals for varied projects in genetics, ecology, behavior, and physiology. The taxonomy of the genus is extremely difficult, largely because of mutual mimicry within the genus and extreme geographical variation and polymorphism within some species. Its study has been somewhat hampered in the past by the absence of illustrations, which in addition makes it difficult for both the amateur butterfly collector and the professional researcher to identify the material with which he is working. Presented here are some pictures of important specimens, most of them types, and most of them never previously illustrated. These are in order: type specimens designated by Felix Bryk, from the Swedish Amazon Expedition, in the Naturhistoriska Riksmuseet, Stockholm; forms of the rare and little known species *Heliconius demeter*; and type specimens of another comparatively rare and difficult species, *Heliconius elevatus*, from the Naturhistorisches Museum, Wien.

Other works illustrating large numbers of *Heliconius* specimens are the two standard monographs (although by no means every species is illustrated) by Stichel & Riffarth (1905) and by Stichel (1906), and the profuse color illustrations by Seitz (1913); all these works are well out of date in their classification. All the Trinidadian species have been illustrated by Beebe, Crane & Fleming (1960), reprinted by Emsley (1963), and all of these appear in color in the recent book by Barcant (1971). Sixteen of the commoner species are figured by Turner (1968)<sup>2</sup>, who has also figured some of the subspecies of *H. elevatus* and *H. melpomene* (Turner, 1967). A great variety of Brazilian species have recently been illustrated by Brown & Mielke (1972) and Brown (1972). The geographical variation of *Heliconius melpomene* and *H. erato* has been illustrated by Brown & Mielke (1972) and in color by Turner (1971).

The butterflies are fully described in the figure legends, but a few

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<sup>2</sup> The alleged *egeria* in that paper is in fact *burneyi*.



Figs. 1-7. Type specimens designated from the Swedish Amazon Expedition, and preserved in the Naturhistoriska Riksmuseet, Stockholm: 1. *H. elevatus taracuanus* Bryk, holotype male (Brasil, Est. do Amazonas, Rio Uaupés, Taracua); 2. *H. erato reductimacula* Bryk, holotype male (data same as 1); 3. *H. aocde aocde* from *postalbimacula* Bryk, holotype male (Brasil, Est. do Amazonas, Manaós); 4. *H. erato estrella* form *aurivillii* Bryk, holotype male (Brasil, "Rio Autaz"); 5, 6, 7. *H. egeria homogena* Bryk, male syntypes, the specimen at figure 6 is hereby designated lectoholotype (Brasil, Est. do Amazonas; 5-6. Rio Uaupés, Taracua; 7, Rio Negro, São Gabriel).

points are worth noting. Among the type specimens from the Swedish Museum in the first photograph are three species (Figs. 1, 2, 5, 6, 7) from the upper Rio Negro; all these forms show very similar patterns, with the yellow marks in the outer area of the forewing more or less fused into a large patch, a feature which tends to be rare to the south on the Amazonas, where the yellow patch tends to be broken up into spots or reduced to a broad yellow bar; there is a strong suggestion here of mutual mimicry among these three species, a mimicry which is known to occur in other parts of their ranges.

Illustrated here for the first time are type specimens of *H. elevatus* carrying the designations *taracuanus*, *pseudocupidineus*, *griseoviridis*, *noeldneri*, and *aquilina*. These represent a slight extension of the work on the taxonomy of this genus in a previous paper (Turner, 1967). The status of the forms appears to be as follows:

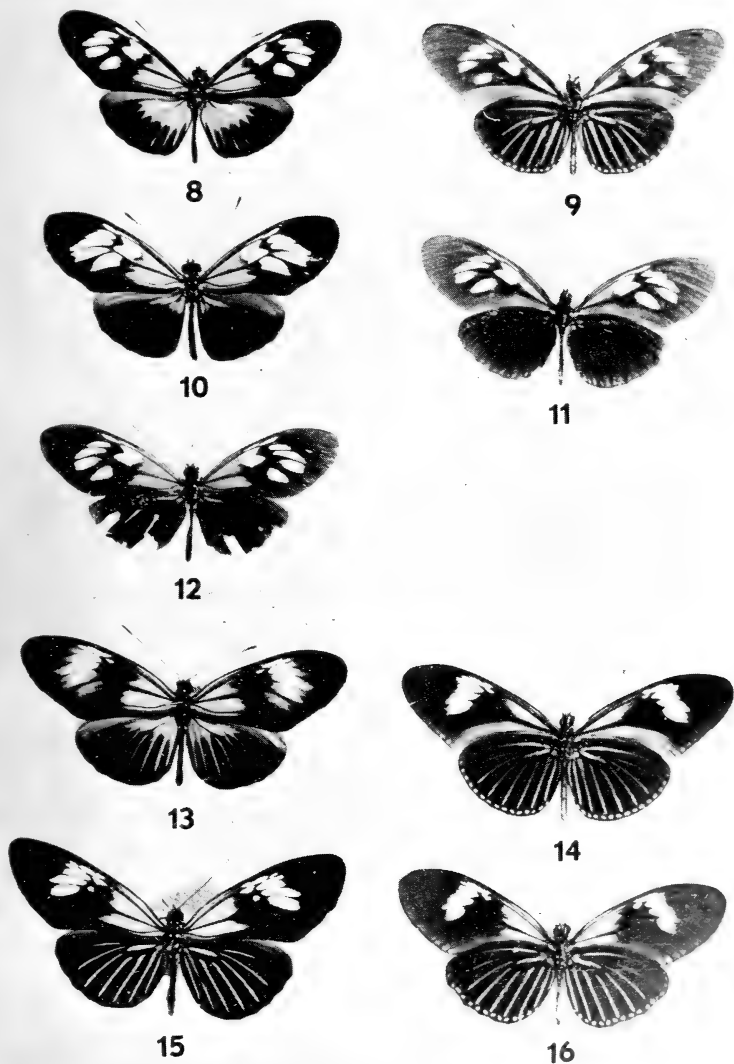
*taracuanus* (Fig. 16): This is probably a good subspecies found in the north Amazon Basin, replaced to the south by nominotypic *elevatus*, and closely resembling the form *perchlora* which is found on the southern border of the Amazon Basin in Bolivia. There is however some variability of patterns in the central Amazon Basin, and the division into these three races may be to some extent arbitrary.

*pseudocupidineus* (Figs. 17, 18): This is a good subspecies confined apparently to the valley of the Rio Huallaga in Peru; it differs from nominotypic *elevatus* in having the yellow band on the forewing extremely narrow (in nominotypic *elevatus* it is of a width intermediate between *pseudocupidineus* and *taracuanus*).

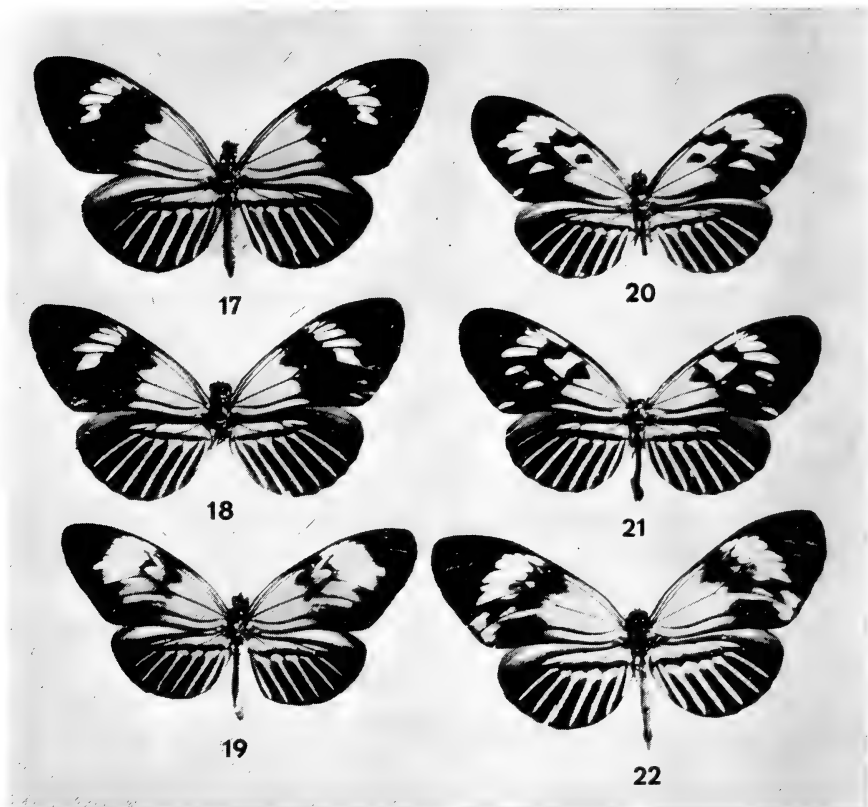
*griseoviridis* and *noeldneri* (Figs. 19, 22): These are probably to be regarded as mere aberrations, although there is no hint about their causation.

*aquilina* (Figs. 20, 21): Populations of *H. elevatus* in the Guianas, lower Amazon and Mato Grosso have the yellow marks on the forewing broken up into dots. The more northerly of these populations have yellow apical spots on the forewing in addition (see illustrations by Turner, 1967); the populations in the south of the range lack these apical spots, as can be seen from the illustration. If one ignores the presence or absence of spots, as being unworthy of producing a subspecific separation, then *aquilina* is a junior synonym of *bari* (Oberthür), the form found in the Guianas; if one wishes to split these populations into two subspecies then *aquilina* is a synonym of *schmassmanni* Joicey & Talbot, which also comes from the Mato Grosso. These names were published during the same year, and date priority has not yet been established.

The full taxonomic references are given elsewhere (Turner, 1967) and



Figs. 8-16. Specimens of *H. demeter* from the British Museum (Natural History), London (uppersides on left, undersides on right): 8, 9. *H. d. bouqueti* Nöldner, males (Guyane française, St. Jean de Maroni); 10. *H. d. bechei* Turner, holotype male (central Guyana—see type description); 11, 12. *H. d. bechei*, paratype females (central Guyana—see type description); 13, 14. *H. d. demeter* Staudinger, males (Peru, Iquitos); 15, 16. *H. d. demeter*, females (Colombia, upper Rio Putumayo, Florida).



Figs. 17-22. Type specimens of *H. elevatus* designated by Neustetter in the Naturhistorisches Museum, Wien, Austria: 17. *H. e. pseudocupidineus* Neustetter, lectoholotype male (Peru, Yurimaguas); 18. *H. e. pseudocupidineus*, lectoparatype female (Peru, Yurimaguas); 19. *H. e. elevatus* form *griseoviridis* Neustetter, holotype male (Peru, Yurimaguas); 20. *H. e. aquilina* Neustetter, lectoholotype male (Brasil, Rio Machados, Mato Grosso); 21. *H. e. aquilina*, lectoparatype female (Brasil, Rio Machados, Mato Grosso); 22. *H. e. elevatus* form *noeldneri* Neustetter, holotype male (Peru, Yurimaguas).

need not be repeated here; a distribution map of the main forms can be found in Turner (1971).

The second photograph illustrates *Heliconius demeter*, which is a very rare species, except possibly in the upper Amazon Basin. Three of the four subspecies are illustrated here: *H. d. bouqueti* from the lower Amazon and Guianas, *H. d. beebei* from the region of the Guiana Shield (these three are the type specimens) and the nominotypic subspecies *H. d. demeter* from the upper Amazon. The fourth subspecies *H. d. eratosignis* is not illustrated, as at the time of taking the photograph only

the two type specimens were known. The forewing resembles that of *bouqueti* and *beebei*, but the rays on the hindwing are separated and not fused into a red patch, even in the male. In the other subspecies (except *beebei*) there is more or less extensive fusion of the rays in the male, although not in the female. The female of *bouqueti* is not illustrated as no specimen could be found to photograph; it has previously been illustrated by Neustetter (1931), under the name *H. eratoformis*. In collections it is about twenty times as rare as the male; the only specimens known to me apart from the type (originally in the Larsen collection and not traced), are one in the collection of Drs. E. H. Jonkers of the Netherlands Government Economic Mission to Suriname, in Paramaribo, and one in the British Museum (Natural History). An account of the complicated synonymy is given elsewhere (Turner, 1966).

We are very grateful to the following for the loan of the specimens photographed: The Naturhistoriska Riksmuseet, Stockholm; the British Museum (Natural History), London; and the Naturhistorisches Museum, Wien. Where necessary, designations of lectotypes are made in the figure legends. The colors are black, red and yellow.

#### SUMMARY

Twenty-two specimens of *Heliconius*, most of them belonging to forms previously not figured, from museums in Austria, England, and Sweden, are illustrated with photographs. Sixteen of these are type specimens of forms in the species *elevatus*, *demeter*, *erato*, *aoede*, and *egeria*. One lectoholotype is designated, and a short account is given of the importance of these specimens. The photographs show a mimicry ring found on the upper Rio Negro, and for the first time, the major subspecies of *Heliconius demeter*.

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## POPULATIONS OF *PAPILIO ANDRAEMON BONHOTEI* SHARPE AND *PAPILIO ARISTODEMUS PONCEANUS* SCHAUS (PAPILIONIDAE) IN BISCAYNE NATIONAL MONUMENT, FLORIDA

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A survey of the Lepidoptera found on the islands of Biscayne National Monument, Florida, in April and May 1972, revealed sizeable breeding populations of two rare papilionid butterflies. These are the Bahaman Swallowtail (*Papilio andraemon bonhotei* Sharpe) and Schaus' Swallowtail (*Papilio aristodemus ponceanus* Schaus). The former species has been recorded only a few times in Florida (Holland, 1902; Clarke, 1940; Kimball, 1965) and until now has been considered only a stray or accidental visitor to United States shores following hurricanes. The scarceness of the latter species in southern Florida has also been previously documented by many authorities including Bates (1934), Grimshawe (1940), Henderson (1945a, 1945b, 1946), Klots (1951) and Rutkowski (1971). The majority of records for Schaus' swallowtail are from Key Largo and Lower Matecumbe Key (Kimball, 1965) which suggests that these islands house the remaining remnant population of this species found in the



United States. However, this proves not to be the case since the species is now found to be prevalent on several remote keys to the north and east of Key Largo.

From 20-24 April 1972, and again from 27-30 May 1972, I surveyed the major islands of Biscayne National Monument. Swallowtails were quite abundant, and in a single day I often encountered as many as 100 *P. aristodemus ponceanus* and a like number of *P. andraemon bonhotei* on these islands. In April large numbers of adult Schaus' and Bahaman swallowtails had recently emerged, as indicated by their perfect condition and unworn scales. Adults were flying in substantial numbers in both the dense hammocks and along the narrow trails which cut through the jungle-like vegetation of the islands. A limited number of reference specimens of each species was collected and preserved.

In late May, nearly all specimens of both species were badly tattered or worn, and many flew rather weakly compared to the previous month. This suggested that the peak emergence had occurred in April or early May, and that most of the adults were nearing senescence. Approximately half of the swallowtails observed and collected in April were *P. andraemon bonhotei*, but in May they comprised only about one-third of the total number encountered.

On two occasions female *P. andraemon bonhotei* were observed in late April laying eggs on the leaves on Key lime (*Citrus aurantifolia*) and sour orange (*Citrus aurantium*) trees. Citrus trees are scattered sparingly throughout the jungle-like forests which cover these keys. Also, one *P. aristodemus ponceanus* was seen laying eggs on the leaves of torchwood or sea amyris (*Amyris elemifera*), which is an abundant understory shrub or small tree on most of the islands surveyed. This agrees with the Grimshawe (1940) and Rutkowski (1971) reports that torchwood is the foodplant for *P. aristodemus ponceanus*. Also, two late instar larvae of this species were located on torchwood in late May 1972.

The relative abundance of these papilionids on the Biscayne Bay Keys suggests that they have a high potential for survival on a long term basis. The two greatest threats to their populations would seem to be: 1) habitat destruction by man or hurricane, and 2) overcollecting by dealers and lepidopterists. Since their prime habitat is now fully under the control and protection of the National Park Service, there seems little chance of total habitat destruction due to man. There is always the possibility of overcollecting, but since a federal collecting permit is required to legally take anything from a national park or monument, it should be relatively easy for the Park Service to police Lepidoptera poaching once they are made aware of the presence of these rare species within their jurisdiction.



Fig. 1. Two *Papilio andraemon bonhotei* Sharpe taken in Biscayne National Monument, Dade Co., Florida, April 1972. Underside (above); upperside (below).

One obvious factor which operates to protect these populations and until now prevented their detection, is the relative isolation of these islands which are located between seven and eight miles from the adjacent Florida mainland. The fact that they can be reached only by boat reduces the probability that collecting pressure will be great. This pressure will probably increase however, once the National Park Service institutes its announced plan of establishing a regular ferry to some of the islands for the benefit of tourists.

Evidence of the ability of these papilionids to colonize adjacent keys or the mainland was noted during the survey. On several occasions while traveling by boat between islands in the chain, both Schaus' and Bahaman swallowtails were seen flying across the open water. On two occasions we collected the butterflies with hand nets after pursuing them by boat for one-fourth mile or more across Biscayne Bay. On one occasion a *P. aristodemus ponceanus* eluded our pursuit and flew safely from the south end of one key and entered the jungle on the northeast side of an adjacent key in a route that covered over one-half mile. It therefore seems certain that movement of these rare species by island-hopping along the chain of Florida Keys occurs routinely. However, since both the Schaus' and Bahaman swallowtails have been recorded somewhat sparingly from Key Largo, Lower Matecumbe Key, and the mainland of the southern Florida, these areas could presently be considered rather marginal when compared to the populations located in Biscayne Bay National Monument. The foodplants for these species are readily available throughout the middle and lower Florida Keys as well as on the mainland; therefore, the explanation for their scarcity there is probably related to overzealous collecting activities by man in past years.

Other species of Lepidoptera which were collected on keys of the Biscayne National Monument during the April-May 1972 survey included the following: *Battus polydamas* (Linnaeus), *Papilio cresphontes* Cramer, *Phoebis agarithe* Boisduval, *Appias drusilla* Cramer, *Phyciodes tharos* (Drury), *Cynthia virginiensis* (Drury), *Junonia evarete zonalis* (Felder & Felder), *Metamorphia stelenes* (Linnaeus), *Eunica tatila* (Herrich-Schäffer), *Hemiargus ammon* (Lucas), *Heliconius charitonius* Linnaeus, *Dryas julia* (Fabricius), *Agraulis vanillae* Linnaeus, *Phocides pigmalion* (Cramer), *Polygonus leo* (Gmelin), and *Urbanus proteus* (Linnaeus).

#### ACKNOWLEDGMENTS

I would like to thank my graduate students, Richard McGuire and Ronald Pscion, as well as members of the University of Terrestrial Ecology class, for assistance in surveying the Lepidoptera of the Biscayne Bay

islands. I also wish to express gratitude to the personnel of the National Park Service and the Dade County Parks Department for cooperation and assistance during this survey.

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#### ON *Glenoides texanaria* (GEOMETRIDAE) WITH DESIGNATION OF THE LECTOTYPE

As Mr. André Blanchard is describing new species of *Glenoides* McDunnough from Texas, it became necessary to definitely establish the identity of *texanaria* (Hulst), the heretofore sole included species of this genus.

Hulst described *Tephrosia texanaria* from a series of eight males and six females, according to the original description. The Hulst collection contained one male; this specimen is hereby designated as the lectotype. It is in the collection of the American Museum of Natural History, and its genitalia are mounted on slide FHR No. 16712.

The species is widely distributed across the southeastern United States. Specimens are before me from eastern Texas, Louisiana, Mississippi, Arkansas, Missouri, Kentucky, and South Carolina. It may occur in Florida, but more study is necessary to determine the status of specimens from that state.

There appears to be some variation in the size of the adults of *texanaria*, being apparently correlated with the time of flight. Moths captured in late fall and early spring months are larger and appear somewhat darker than those taken from May through September.

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A NEW SPECIES OF THE  
GENUS *GLENOIDES* McDUNNOUGH (GEOMETRIDAE)

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Hulst (1888) described *Tephrosia texanaria*, which he later (1896) moved to his new genus *Glena* (orthotype *cognataria* Hbn.). McDunnough (1920) recognized that *texanaria* is not congeneric with *cognataria* and created for it the monotypic genus *Glenoides*.

***Glenoides lenticuligera* A. Blanchard, new species**

**Head:** Smoothly scaled; vertex pale brownish; front broadly black, with upper and lower, narrow, white borderlines; palpi short, porrect, projecting only slightly beyond front; male antennae bipectinate with short, simple apical section; each pectination bearing a double row of cilia and a longer seta at apex; female antennae roughly scaled above and laterally, ciliate below.

**Thorax:** Pale brownish, spotted with dark brown above; legs slender, smooth, male without hair pencil, blackish externally, all segments of tarsi distally ringed with white.

**Abdomen:** Pale brownish, except segments three and four which are dark brown above.

**Pattern of maculation** (Figs. 1-4): Ground color of forewing pale brownish, sprinkled with brown scales, more heavily along costa, and in subterminal and terminal spaces; four dark brown blotches about equally spaced on costa, three innermost ones mark the origins of a.m. line, median shade, and p.m. line, fourth blotch adnate to and basad of s.t. line; a.m. line brown starting on costa one fourth distance from base to apex, regularly and outwardly convex, reaching inner margin one-fifth distance from base to tornus; p.m. line brown, starting on costa two-third distance from base to apex, roughly parallel to outer margin; s.t. line of ground color, irregular, slightly retracted between veins, more so in cell  $Cu_1$ , inwardly bordered by dark brown blotches, of which the most conspicuous straddles vein  $M_2$ , terminal black dots in all cells between, and generally including,  $R_4$  to  $Cu_2$ . Hindwing patterned in direct continuation of forewing, with well marked black discal dot. Pattern of maculation beneath similar but fainter on paler, less freckled background.

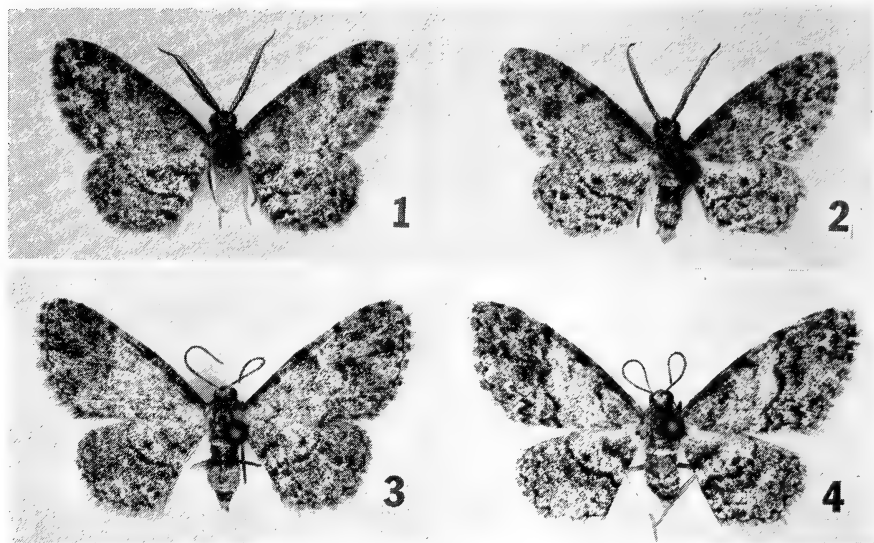
**Length of forewing:** Male 7.2 to 8.0 millimeters (average 7.7 mm); female 8.0 to 8.8 millimeters (average 8.4 mm).

**Male genitalia** (Fig. 5): Valves unarmed; juxta replaced by two spinose processes, one on each side; aedeagus with a row of four to six teeth on outer margin; vesicae armed with numerous cornuti.

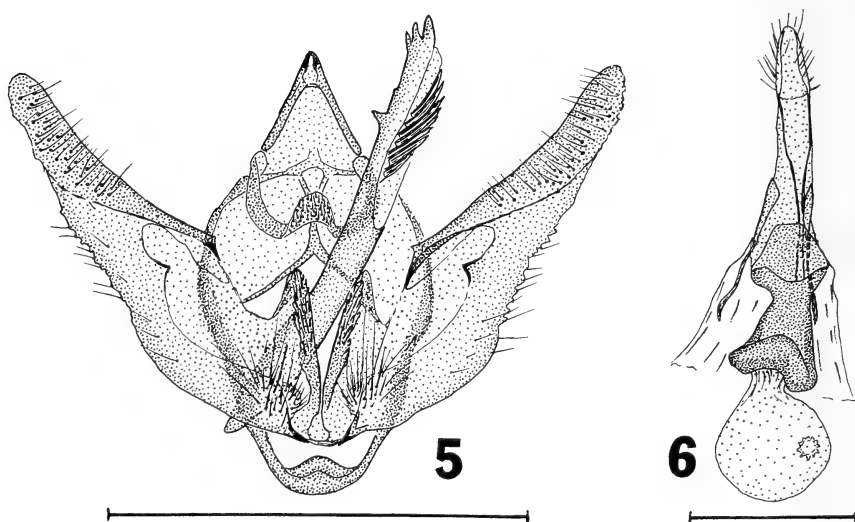
**Female genitalia** (Fig. 6): Ovipositor lobes appear membranous; a heavily sclerotized, hourglass shaped combination of sterigma and ductus bursae presents a short ventral fold; small star-shaped signum on lateroventral right side of nearly spherical bursa.

**Holotype:** Male, Santa Ana National Wildlife Refuge, Hidalgo Co., Texas, 15 February 1971, deposited in the National Museum of Natural History (No. 72326—genitalia slide A.B. 2633).

**Paratypes:** Santa Rosa (Longoria unit of Las Palomas Wildlife Management Area) Cameron Co., Texas, 21 Nov. 1966 (one ♂). Brownsville (Voshell unit of Las Palomas Wildlife Management Area) Cameron Co., Texas, 10 & 12 Nov. 1968



Figs. 1-4. *G. lenticuligera*: 1, male holotype, Santa Ana Refuge, 15 Feb. 1971; 2, male paratype, Santa Ana Refuge, 15 Feb. 1971; 3, female paratype, Brownsville, 12 Nov. 1968; 4, female paratype, Santa Ana Refuge, 14 Nov. 1971.



Figs. 5, 6. *G. lenticuligera*, genitalia: 5, male holotype (A.B. 2633); 6, female paratype, Santa Ana Refuge, 13 Nov. 1971 (A.B. 3033). (Linear segments represent one millimeter.)

(two ♀♀); 5 to 9 Nov. 1969 (two ♂♂, one ♀); 26 Oct. 1970 (one ♂); 18 Nov. 1971 (two ♂♂). Santa Ana National Wildlife Refuge, Hidalgo Co., Texas, 23 Oct. 1970 (one ♂); 15 & 16 Feb. 1971 (three ♂♂, one ♀), 13 to 16 Nov. 1971 (four ♂♂, ten ♀♀); 7 April 1972 (five ♂♂, eight ♀♀). Paratypes will be deposited in the National Museum of Natural History, in the American Museum of Natural History and in the British Museum (Natural History).

The new species is quite close to *Glenoides texanaria*, the only other taxon in the genus; the pattern of maculation is nearly the same, but the transverse lines of *texanaria* are much better defined and its background is nearly clean of scattered brown scales and dark blotches; *G. texanaria* is appreciably larger; the unmistakable differences between the two species are however in the genitalia: the vesica of the male *texanaria* is unarmed and the postvaginal plate of its female presents an elongated sclerotization which does not exist in *G. lenticuligera*.

#### ACKNOWLEDGMENTS

It is a pleasure to acknowledge with thanks the generous help which I received from Drs. D. C. Ferguson of the Entomology Research Division, U.S.D.A. and F. H. Rindge of the American Museum of Natural History in preparing this paper. I am also grateful to the Bureau of Sport Fisheries and Wildlife (Albuquerque, New Mexico) and to the Park and Wildlife Department (Austin, Texas) for the authorization that they gave me to set traps in the territories under their jurisdiction.

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#### MIDGES (DIPTERA: CERATOPOGONIDAE) SUCKING BLOOD OF CATERPILLARS

With reference to Willis W. Wirth's note under this heading (1972, J. Lepid. Soc. 26: 65), I have a record of a larva of *Acherontia atropos* L. (Sphingidae) bearing seven of these small midges. The larva was found in Kampala in July 1950, and was carried by car for over a mile clinging to a twig without disturbing the midges. My notes state that the larva appeared to suffer no inconvenience and that there was no exudation of fluid from the punctures, which were invisible under a hand lens, when the midges were removed.

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NOTES ON VIRGINIA BUTTERFLIES, WITH TWO  
NEW STATE RECORDS<sup>1</sup>

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In 1951 Austin and Leila Clark published *The Butterflies of Virginia*. This work crowned 20 years of avid collecting and observation in the Old Dominion by the Clarks and their colleagues, and brought together all the records and knowledge about the Virginia butterfly fauna up to that time. According to the nomenclature used by the Clarks, a total of 154 species and subspecies (144 species) was recorded as having been collected in Virginia. Keys, diagnostic features, range, variation, occurrence, season, and interesting discussions were given for the butterflies and a complete bibliography of literature on Virginia butterflies rounded out the work.

Since the appearance of Clark & Clark (1951) very little has been published to add to our knowledge of the Virginia butterfly fauna. Covell (1962) added *Satyrrium kingi* (Klots & Clench) to the State list and Straley (1969) recorded *Thymelicus lineola* (Ochsenheimer) for the first time from the State. Nomenclature and arrangement of species were brought into line with dos Passos (1964), the present standard for North American Rhopalocera classification, by Covell (1967). The latter list also included the first record of *Megathymus yuccae* (Boisduval & Le Conte) for Virginia.

In this paper we include two more first records for the State—*Problemabulenta* (Boisduval & Le Conte) and *Satyrrium caryaevorus* (McDunnough). In accordance with the dos Passos arrangement, plus recent changes in the nomenclature of *Lethe*, 158 species and subspecies (149 species) of butterflies are now known to have been taken in Virginia.

Nomenclature and arrangement of species employed in this paper follow dos Passos (1964, 1970) and other recent works; but references are made to coverage of the species in Clark & Clark (1951). Botanical nomenclature follows Massey (1961).

Our purpose in writing this paper is to add our records and observa-

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<sup>1</sup> University of Louisville Contribution in Biology, No. 155 (New Series).



tions on certain butterfly species to those of the Clarks, thus bringing *The Butterflies of Virginia* more nearly up to date. In addition to our own records we include information from others who have collected in the State in the past 20 years and records from the Field Season Summaries of the *News of the Lepidopterists' Society*.

We concentrate our attention on the rarer species in the State, giving range extensions and new county records for species previously known from only a few counties. We hope that this additional information will be of value in helping other collectors find new collecting areas, especially for the rarer species in Virginia.

Covell's records from the Commonwealth span the years 1952 to 1971, with most of his collecting having been done between 1958 and 1964. He visited 81 counties, taking at least 5 butterfly species in each. Straley has actively collected from 1963 to the present. We have both resided in several different areas of the State and have concentrated on those areas; both our efforts, combined with those of other collectors, have encompassed most of the State. We have both done our most intensive collecting in the Norfolk-Virginia Beach area, and in Giles and Montgomery counties.

Specimens have for the most part been retained in our private collections. However, a large amount of representative material has been placed in the collection of the Entomology Department of Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Further information on species treated is available from the authors.

In recent years there have been several changes in political boundaries in Tidewater Virginia, which might cause some confusion when one compares records in this paper with those of Clark & Clark (1951). The counties of Norfolk, Princess Anne, Warwick, and Elizabeth City no longer exist. The City of Norfolk is the same; but the remainder of old Norfolk County is now the City of Chesapeake, Princess Anne County is now the City of Virginia Beach, Warwick County is the City of Newport News, and Elizabeth City County is now the City of Hampton.

## Treatment of Selected Species

### MEGATHYMIDAE

*Megathymus yuccae* (Boisduval & Le Conte). We know of no other records of this skipper since the sighting of larval tents by the late F. H. Chernock near Sandbridge, Virginia Beach [reported in Covell (1967), p. 21], although several colonies of *Yucca filamentosa* L. have been checked in Virginia Beach on several occasions by Straley and Anderson.

### HESPERIIDAE

*Panoquina panoquin* (Scudder). *Panoquin* has been observed quite often straying for some distances from its salt marsh habitat into open fields and the edges of woods.

We have taken it commonly on flowers of white clover (*Trifolium repens* L.), sweet pepper bush (*Clethra alnifolia* L.), and the blue mist-flower (*Eupatorium coelestinum* L.). Covell added a new county record: King and Queen Co., near West Point, 15 Sept. 1962.

*Panoquina ocola* (Edwards). We have three new county records in the State for *ocola*: Giles (Straley), Montgomery and Middlesex (Covell), which support the Clarks' observation that *ocola* occurs in the Coastal Plain and southwestern mountains, but not in the heart of the Piedmont (p. 186).

*Amblyscirtes aesculapius* (Fabricius). We have found this skipper, known by the Clarks as *textor* Hübner, common in many areas of southeastern Virginia. The Clarks (p. 180) mention that it is attracted to the flowers of *Prunella* and *Elephantopus*. In addition to these we have taken it frequently on white clover, dogbane (*Apocynum cannabinum* L.), and sweet pepper bush, mostly at the edges of woods and along forest paths. We agree with the Clarks that there is a spring brood, as we have found it in late April and early May.

*Amblyscirtes carolina* (Skinner). *Carolina*, another flower visitor, tends to hug the ground in flight. We have found it especially attracted to flowers in the rose family, i.e. blackberry (*Rubus*), cinquefoil (*Potentilla*), and strawberry (*Fragaria*), as well as sweet pepper bush, swamp milkweed (*Asclepias incarnata* L.) and others. The form *reversa* Jones needs a great deal more critical field and laboratory study. A number of collectors feel that *reversa* may be a distinct species rather than a form of *carolina*.

*Atrytonopsis hianna* (Scudder). Records of this species from Montgomery (VPI Collection) and Giles (Straley) extend the range somewhat westward in Virginia. Even more interesting, however, are Anderson's records from Nansemond, Chesapeake, and Virginia Beach (6 to 24 May) which are the first known captures of *hianna* in southeastern Virginia. It probably occurs throughout the State.

*Euphyes palatka* (Edwards). Although several collectors have searched diligently for *palatka* in southern Virginia Beach where Otto Buchholz took it, none had been found since his records of 1944. Finally, in 1971, Anderson succeeded in collecting a male on 7 June on pickerelweed (*Pontederia cordata* L.) in Currituck County, North Carolina, just across the State line from Virginia Beach, and another male on 11 June at Blackwater in Virginia Beach. *Palatka* may venture this far north only sporadically.

*Euphyes dion dion* (Edwards). A record of *dion* in New Kent County (Straley) extends the range of this subspecies slightly northward in Virginia. It was previously known only from three counties bordering North Carolina.

*Euphyes dion alabamiae* (Lindsey). Although it is now generally considered a subspecies of *dion*, *alabamiae* was thought to be a distinct species by the Clarks (p. 174). Dr. Lee D. Miller (pers. comm.) has collected and examined individuals from the Dahl Swamp, Accomack County, that the Clarks considered *alabamiae*. He is of the opinion that this population may be an undescribed subspecies—not *alabamiae*. This is another species-subspecies complex which needs more careful study.

*Euphyes dukesi* (Lindsey). *Dukesi* can be collected in quantity on pickerelweed flowers along the North Landing Road and at Blackwater in Virginia Beach. The Clarks (p. 176) did not realize that it has a fall brood. We have fall records from 2 August to 9 September in the localities mentioned by the Clarks.

*Poanes yehl* (Skinner). We must disagree with the statement by the Clarks (p. 172) that *yehl* is "exceedingly shy and difficult to catch." We have found it very easy to net on numerous occasions, especially when it is visiting its favorite flowers—pickerelweed, swamp milkweed, and sweet pepper bush. *Yehl* is one of the most common skippers flying in southeastern Virginia during late July and August.

*Problema bulenta* (Boisduval & Le Conte). **Figs. 1-4.** The discovery of this little-known skipper in Virginia is without doubt the most exciting addition to the butterfly fauna of the State in recent years. It was first collected in the State by John Bauer and Bruce Dixon, 21 August 1967, about two miles south of the town of



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Figs. 1-7. Virginia butterfly specimens: 1, 2. *Problema bulenta*, male, New Kent Co., 17 Aug. 1970, upper and lower aspects; 3, 4. *P. bulenta*, female, same data as male, upper and lower aspects; 5, 6. *Thymelicus lincola*, male, Eggleston, Giles Co., 21 June 1968, upper and lower aspects; 7. *Satyrium caryae*, female, Eggleston, Giles Co., 4 July 1963, lower aspect.

Lanexa, along the Chickahominy River in the extreme southeastern corner of New Kent County. One female was placed in the Carnegie Museum in Pittsburgh and presumably forgotten until July 1970, when Nicolay and Straley were visiting the museum and noticed the specimen.

The Virginia locality was visited several times that August by Anderson, Nicolay, Covell, and Straley; and after many hours of collecting, an additional 14 males and 4 females were taken, all on the flowers of swamp milkweed. Hoping to find an earlier brood, Anderson searched the area unsuccessfully on 19 July 1971; but he and Nicolay did take two more males in August, 1971.

The habitat for *bulenta* is the broad expanse of marshy flood plain of the Chickahominy River. The dominant plants along the river are pickerelweed, swamp milkweed, buttonbush (*Cephalanthus occidentalis* L.), rose mallows (*Hibiscus moscheutos* L.), cattails (*Typha* sp.), and various grasses and sedges, all partially submerged at high tide. Islands and peninsulas of higher ground support shrubby dogwoods (*Cornus* sp.), bald cypress [*Taxodium distichum* (L.) Richard], and black gum (*Nyssa sylvatica* Marsh). Due to the extensiveness of the marshy area along the Chickahominy and the James River into which it flows, it seems likely that *bulenta* may occur widely in the area. Accessibility to much of the area is limited—a problem which may be solved by use of a boat for collecting.

*Wallengrenia otho otho* (Smith). The Clarks (p. 167) recognized two subspecies: *otho otho* (with dull orange or orange-red ground color on the hindwings beneath), and *otho egeremet* (Scudder) (with dark purplish-brown ground color on the hindwings beneath). According to the records cited by the Clarks, *otho otho* occurs in the Piedmont and Coastal Plain, and *otho egeremet* flies throughout the State, including areas where *otho otho* has been collected. Our own records from the Dismal Swamp, New Kent County, and Virginia Beach indicate that the two forms are sympatric in these areas. We feel that the differences in pigmentation may be due to diet or otherwise environmental in nature, and do not indicate subspeciation. Sympatry could indicate that the two are separate species. Perhaps careful study of the differences will clarify the situation.

*Hesperia metea* Scudder. The Clarks list six county records for this species and state (p. 160) "undoubtedly much more generally distributed in the western part of the State than these records would indicate." We support this statement with four additional county records: Stafford (Nicolay), Henry and Giles (Straley), and Rappahannock (Ferris). We have found it attracted to low-growing flowers especially those in the Rosaceae. It can also be found flying about grassy clearings among cedar groves on limestone outcrops, as Covell found in Montgomery Co.

*Hesperia leonardus* Harris. Covell has taken *leonardus* in three additional counties—Powhatan, Prince William, and Stafford. The Powhatan County record shows its range extends more into central Virginia than indicated by the Clarks (p. 160).

*Thymelicus lineola* (Ochsenheimer). **Figs. 5-6.** Straley (1969) reported the first known occurrence of the European Skipper in Virginia in the mountains in Giles County. Mitchell took two males in Poverty Hollow in neighboring Montgomery County on 22 June 1969. Straley found it fairly common but worn on 3 July 1971, in a meadow near the original locality; and Showalter also took it in 1971 at Blacksburg in Montgomery County. *Lineola* is probably well established in western Virginia and probably now even farther south and east.

*Staphylus mazans hayhurstii* (Edwards). The Clarks (p. 153) mention that *hayhurstii* is confined to the Coastal Plain. We have additional records in the eastern part of the State for Stafford (Nicolay), Virginia Beach and Northumberland (Straley). A most surprising capture of this species was made by Straley in Henry County in the western edge of the Piedmont. A male was first taken in a weedy area in Martinsville on 30 June 1969; three males and a female were taken in the same locality on 30 July 1969; and a male was caught on 23 May 1970, near the town of Figsboro, also in Henry County. These records extend the range of *hayhurstii* about two hundred miles westward in Virginia.

*Urbanus proteus* (Linnaeus). Covell has three additional Coastal Plain county records: Middlesex, Nansemond, and Chesapeake, all in late September 1959.

#### PIERIDAE

*Colias eurytheme* Boisduval. **Figs. 12-15.** There is always a great deal of variation in *eurytheme* and its hybrid with *philodice*, both seasonally and among specimens caught at one time in any one locality. Straley has taken four aberrations of this



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Figs. 8–11. *Satyrium kingi* from Virginia: 8, 9, male, near Suffolk, Nansemond Co., 21 June 1970, upper and lower aspects; 10, 11, female, same data as male, upper and lower aspects.

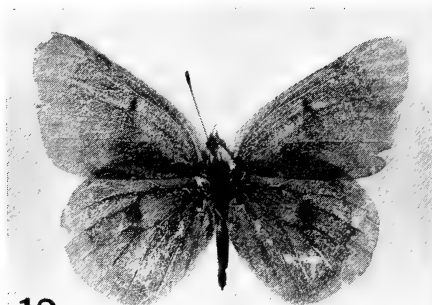
common butterfly while searching for more choice species. All were collected in open grassy meadows just north of Buckeye Mountain about three miles west of the town of Eggleston, in Giles County.

The most unusual was a melanic male taken on red clover (*Trifolium pratense* L.) on 6 September 1965 (Figs. 12, 13). The upper surface is a dark sooty brown, lightly dusted with yellow scales basally. The normally black borders are lighter brown than the rest of the wings. On the lower surface the hindwings are a uniform dull yellow and the forewings are dull brown with yellow tips and costal margins.

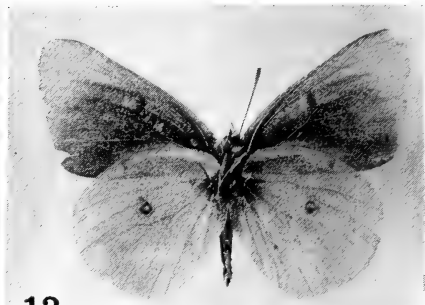
The other three aberrations are all similar on the lower surface. All have black streaks from the submarginal row of spots inward on the underside of the forewings and a brown patch or broad brown streaks from the submarginal spots inward on the hindwings. The first specimen of this aberration was collected on 19 June 1962. The upper surface was normal except for a noticeable pink iridescence in the orange ground color. The second specimen (Figs. 14, 15) was an orange female taken on 22 September 1965. It has wide black borders extending into the spot at the end of the cell on the upper surface of the forewings. The submarginal yellow spots in the black border are greatly reduced and smudged. A white female was collected on 24 April 1966, with the upper surface normal. The under surface, however, has the same black-streaked forewings and brown-streaked hindwings.

#### RIODINIDAE

*Calephelis virginiensis* (Guérin-Méneville). This small postmark was recorded from four localities in only two counties—Princess Ann (now Virginia Beach)



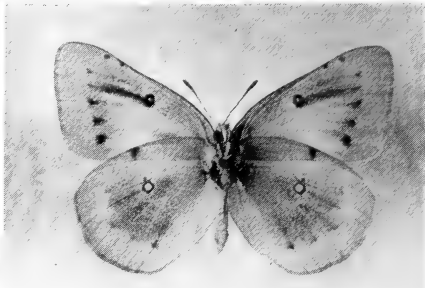
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Figs. 12-15. *Colias eurytheme* from Virginia: 12, 13. melanic male, Eggleston, Giles Co., 6 Sept. 1965, upper and lower aspects; 14, 15. aberration female, Eggleston, Giles Co., 22 Sept. 1965, upper and lower aspects.

and Nansemond. We have found it in three other locations in Virginia Beach (Anderson & Straley), three in Chesapeake (Anderson & Covell), and one in the City of Norfolk (Anderson). The best locale we have found for *virginiensis* is a low, weedy roadside ditch along London Bridge Road at Oceana Naval Air Station in Virginia Beach, where eighteen specimens were taken in a short time one day. This species is probably more widely distributed than our records indicate, but is easily overlooked owing to its small size, restricted occurrence, and probably short flight period for each brood. Adults seem to prefer alighting on broad leaves, but they often visit the flowers of the blue mist-flower (*Eupatorium coelestinum* L.).

*Calephelis borealis* (Grote & Robinson). The Poverty Hollow (Montgomery County) colony of *borealis* continues to flourish. It has been found there regularly in recent years by a number of collectors. Covell found another colony in Montgomery County along Slusser Chapel Road. Kenneth Frank discovered a colony at Nature Camp, near Vesuvius, in Rockbridge County, which is a new county record. This brings to five the number of counties in Virginia in which *borealis* is known to occur.

#### LYCAENIDAE

*Harkenclenus titus mopsus* (Hübner). The Clarks (p. 79) record *mopsus* from seven counties only in the Piedmont and Shenandoah Valley of the State. We have additional records from Giles (Straley), Rappahannock (Ferris), Stafford (Nicolay), Nansemond (Anderson), Middlesex and Gloucester (Covell). The latter three counties extend the range of *mopsus* into the Coastal Plain. It should be looked for

throughout the State, especially on the flowers of butterflyweed (*Asclepias tuberosa* L.) and common milkweed (*Asclepias syriaca* L.).

*Satyrium liparops strigosa* (Harris). This subspecies is recorded from five counties in the State by the Clarks (p. 81). We have three additional records: Rockbridge (Covell), Alleghany (Clench), and Giles (Straley). Although it is probably not "rare" as the Clarks say, it is certainly not easily encountered.

*Satyrium kingi* (Klots & Clench). **Figs. 8-11.** Covell (1962) recorded the first capture of *kingi* in Virginia on 11 June 1958. Unfortunately the locality near the Norfolk Airport is in the heart of the urban expansion of the cities of Norfolk and Virginia Beach, and an elementary school now stands where *kingi* once flew. Several other localities have, however, been discovered by other collectors in the State. Miller collected one worn female five miles south of Suffolk on the west side of the Dismal Swamp.

Anderson found it near the Suffolk Airport on 16 July 1967. This spot has been collected every year since then by several collectors and has yielded a large number of specimens. The locality is a second growth mixed deciduous woods. Males have been noted visiting the flowers of sourwood [*Oxydendrum arboreum* (L.) DC.] where they are easily taken, especially with a long-handled net. More commonly they sit on the tops of broad leaves and sun themselves. The females tend to fly lower among the underbrush and they might even be called sluggish for a hairstreak. We have rarely seen the females visit flowers.

Another colony of *kingi* was found by Straley in July 1971, in Chesapeake on the east side of the Dismal Swamp at the junction of routes 104 and 190, in the same type of cut-over deciduous woods. There are undoubtedly other colonies in the Coastal Plain of Virginia which should be sought beginning about 10 June.

*Satyrium calanus falacer* (Godart). We have found *falacer* present, although not common, in the southeastern counties and cities of Norfolk, Chesapeake (Anderson), Nansemond and Virginia Beach (Straley), where it was previously unrecorded. *Falacer* is at times very common in the mountains of the southwestern part of the State, especially attracted to New Jersey tea (*Ceanothus americanus* L.), common milkweed, and dogbane.

*Satyrium caryaevorus* (McDunnough). **Fig. 7.** The first known record of this northern hairstreak in Virginia is from Giles County in the mountains. One female was taken on New Jersey tea by Straley on 4 July 1963. The specimen was thought at that time to be a female *falacer* and was papered and not identified until 1970. The determination was confirmed by Nicolay. It has been compared with a number of *caryaevorus* from Connecticut and New York and matches them quite closely.

The locality is a steep dry hillside just north of Buckeye Mountain about three miles west of the town of Eggleston. The foodplant, hickory (*Carya* sp.), is scattered over the hillside and is common on Buckeye Mountain. The area has been collected briefly on two occasions since 1963, but no more *caryaevorus* have been taken. A more thorough search of the area and similar habitats in early July should turn up more specimens.

*Satyrium edwardsii* (Saunders). The Clarks (p. 80) record *edwardsii* from only four counties. Covell has an additional four: Montgomery, Middlesex, King and Queen, and Gloucester. This is another species of hairstreak which has probably been overlooked in most of the State, and is sometimes locally common in season.

*Callophrys irus* (Godart). We have additional records for *irus* in Stafford (Nicolay) and two locations in Montgomery (Mitchell). *Irus* is probably more widespread than our records indicate. It should be sought where the foodplant, lupine (*Lupinus perennis* L.), grows.

*Callophrys henrici* (Grote & Robinson). We have new county records for *henrici* from nine counties, four of which are in the Coastal Plain, from which there were previously no records. The counties are: Giles and Northumberland (Straley), Stafford (Nicolay), Rappahannock (Ferris), Goochland (Powell), Virginia Beach

(Anderson), Middlesex, King William, and Nansemond (Covell). It should be considered common on the Coastal Plain and generally distributed across the State as the dominant Elfin species.

We have found *henrici* most common along the wooded trails in Seashore State Park, Virginia Beach, on the very first warm days of spring. It rests on sunny spots on the trails or on broad leaves where it is easily netted. In other localities it may be caught on redbud blossoms.

*Callophrys augustinus croesioides* Scudder. *Augustinus* was also not recorded from the Coastal Plain of Virginia until Covell took it in Chesapeake on 23 April 1960. It was taken by Straley in Northumberland and in a second locality in Chesapeake in 1971. It should be expected throughout the State, often flying with *henrici*.

*Callophrys gryneus* (Hübner). Covell took a striking aberrational female among the red cedars on a limestone outcrop near the tunnel at Pepper Station, Montgomery Co., 26 April 1962. The underside is generally brown with dark olive suffusion, and all the white lines and other markings are very obscure and dark, contrasting very little with the ground.

*Atlides halesus* (Cramer). We agree with the Clarks (p. 77) that *halesus* is not very common in southeastern Virginia, but is regularly present and easily overlooked because of its tendency to stay high up in the trees. We found it most common on the flowers of devil's club (*Aralia spinosa* L.) where a long handled net is a necessity for collecting any number of specimens. Occasionally it comes down to the flowers of sweet pepper bush and climbing hempweed [*Mikania scandens* (L.) Willd.].

*Euristrymon ontario* (Edwards). Clench (1971) recorded *ontario* from Alleghany County, Virginia. His five specimens represent the largest number of this species taken at any one locality in the State. It has also been taken in Middlesex (Covell), bringing to five the total number of counties in which it has been found in Virginia. It is probably not an "infrequent casual" as the Clarks (p. 80) say, but is present in isolated colonies which have been mostly overlooked.

*Panthiades m-album* (Boisduval & Le Conte). We have additional records for *m-album* in the following counties: Giles (Straley), Rappahannock (Ferris), Rockbridge (Covell), Chesapeake (Anderson & Straley), Stafford and Virginia Beach (Nicolay). Most of these records represent captures of single specimens, supporting the Clarks' statement (p. 78) that *m-album* is apparently a permanent resident, but often of irregular occurrence in any one place. We have taken it most commonly in Chesapeake, attracted to the flowers of sourwood and especially sweet pepper bush.

*Erora laeta* (Edwards). At the time the Clarks completed their work on the Virginia butterflies in 1951, only one specimen of the Early Hairstreak was known to have been taken in Virginia (Mountain Lake, Giles County, 23 June 1938). A second specimen, a fresh female, was collected by Straley with his fingers at Eggleston, also in Giles County, on 7 May 1964, on moist sand on the bank of New River. The location was near a wooded area, but not a typical habitat where one might expect *laeta*. Mitchell also took a specimen in neighboring Montgomery County in Poverty Hollow, 27 April 1969.

The only multiple capture of *laeta* in Virginia was by Wagner in July 1970, again in Giles County, on the road between Mountain Lake and West Virginia. In a letter dated 19 July 1970, Wagner stated, "I have seen over two dozen *Erora laeta*! . . . There is a spot along the West Virginia Road where you can see two or three at a time." He took nine specimens, but spent a great deal of time just observing *laeta*, hoping to learn more about the habits of this elusive hairstreak. Unfortunately, because of a sudden change of weather to dark and rainy lasting for more than a week, the butterflies disappeared and the investigations ceased.

#### NYMPHALIDAE

*Speyeria diana* (Cramer). This favorite of collectors can still be collected commonly in the vicinity of Brush Mountain, just west of Blacksburg in Montgomery



Co., and probably in many other localities in the lower mountainous regions of Virginia. Covell found that the males appeared in the first week in July, not finding any in late June, during 1960-62. They at first kept to the higher elevations (around 2,000-2,500 ft.), flying along and alighting in the dirt road atop Brush Mountain. There they might be found visiting animal excrement or carrion. After a few days they would be found visiting flowers of the milkweeds *Asclepias tuberosa* L. and *A. syriaca* L., growing in bends in Rt. 460 down the eastern slope, and in Poverty Hollow at the bottom of the western slope of Brush Mountain. The affinity of *diana* for milkweed blossoms—especially *A. tuberosa*, the Orange Milkweed or Butterfly-weed—seems general for the species, as Covell has collected both sexes on these flowers in North Carolina and Kentucky as well. Mitchell has reported good catches of *diana* in this general area in more recent years. The middle of July seems the best time to seek both sexes in good condition.

The Clarks (p. 57) also mentioned Coastal Plain populations of *diana*, recorded from counties south of the York River (Chesterfield and James City south into Nansemond counties). The continued presence of the species in this general area was indicated by the capture by Covell of males on *A. tuberosa* beside Rt. 33 a few hundred yards from its junction with Rt. 17 at Glenns in Gloucester Co. The species was seen there on 19 June 1958, and males were collected there on 25, 26, and 27 June. As in the mountains, species visiting *Asclepias* with *diana* included *S. cybele* and *Harkenclenus titus mopsus*. These captures represent a new county record as well as a slightly northern range extension in the Coastal Plain, apparently the first taken north of the York River.

#### SATYRIDAE

*Lethe portlandia anthedon* (Clark). The Clarks (p. 31) record this butterfly from only four mountain counties in the western part of the State. We can add two additional counties: Montgomery (Covell & Straley, four locations) and Rockbridge (Kenneth Frank). The Clarks mention only one brood; but we have records for every month from 20 May to 4 Aug., indicating at least two broods, maybe three. All our records are for captures of single specimens.

*Lethe appalachia* R. L. Chermock. This species was referred to by the Clarks and by Covell (1967) as a subspecies of *L. eurydice* (Johansson). In accordance with Cardé, Shapiro & Clench (1970), we here refer to *appalachia* as a valid species. Note the Virginia records, including paratypes, cited on p. 87 of Cardé, Shapiro & Clench, adding to those of the Clarks (p. 32). Covell found a small colony in grassy backwaters of a pond in Poverty Hollow, Montgomery Co., in 1960, and the two following years (18-31 July).

#### ACKNOWLEDGMENTS

We wish to express our gratitude to the following for their help in the form of records and other valuable information and assistance in preparing this manuscript: LCDR Richard A. Anderson, Fayetteville, N.C.; Mr. Harry K. Clench, Carnegie Museum, Pittsburgh, Pa.; Mr. William D. Field, U.S. National Museum, Washington, D.C.; Mr. Kenneth Frank, Boston, Mass.; Dr. Lee D. Miller, Allyn Museum of Entomology, Sarasota, Fla.; Mr. Judson T. Mitchell, Blacksburg, Va.; Col. Stanley S. Nicolay, Virginia Beach, Va.; Mr. Richard Pine, Bayside, N.Y.; Mr. Llewellyn Powell, Richmond, Va.; Mr. Amos Showalter, Waynesboro, Va.; and Dr. Warren H. Wagner, Jr., University of Michigan, Ann Arbor, Mich. For the photography we are indebted to Warrant Officer G. G. Thomas and S/Sgt. Richard E. Banzal, USMC.

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A MASSIVE MIGRATION OF *KRICOGONIA* (PIERIDAE) IN CAMPECHE, MEXICO

Byers (1971, *J. Lepid. Soc.* 25: 124-125) notes that, "... this is the first record of a migration of a species of *Kricogonia*," and, "Recent books on insect migration . . . do not mention the genus." My article on migrations (1959, *J. Lepid. Soc.* 13: 62-64) must have been overlooked, as I recorded the migration of *Kricogonia lyside* Godart. Attention must also be called to articles by Clench (1965, *J. Lepid. Soc.* 19: 223-224), Heitzman (1962, *J. Lepid. Soc.* 16: 249-250), Howe (1964, *J. Lepid. Soc.* 18: 26), and Welling (1964, *J. Lepid. Soc.* 18: 229-230).

dos Passos (1964, A Synonymic List of the Nearctic Rhopalocera. *Mem. Lepid. Soc.* 1, p. 46) refers to two species, *K. lyside* Godart 1819, and *K. castalia* (Fab.) 1793. de la Torre y Callejas (1958, Reconsideración Taxonómica de las Especies del Género *Kricogonia* Reakirt con Vista al Estudio de sus Órganos Genitales. Publ. Univ. Oriente, Santiago, Cuba) refers to *K. lyside* and *K. castalia* as being a single species, and *K. cabrerai* Ramsden 1920 as the other. As to which species we may be referring to, much must be left to speculation. Klots (1951, A Field Guide to the Butterflies. Houghton-Mifflin, Boston) notes that a thorough study of the complex needs to be made, most records being untrustworthy.

I take this opportunity to record another great migration of *Kricogonia*. I first note that 1971 seemed to be a year of intense rainfall in the Yucatan peninsula, after a few years of fair to mediocre precipitation. In my prior article (1959, op. cit.) I refer to dry year cycles alternating with wet year cycles, and migrations seeming to be associated with the latter. On 9 June 1971, on passing south of the city of Campeche, Campeche, and until reaching Escárcega, Campeche, I observed the heaviest migration I have ever seen of any kind of insect. Once again it was our commonly-reported *Kricogonia* sp. The heaviest part of the migration was slightly south of Lerma, through the villages of Sihochac, Seybaplaya, Haltunchén, Champotón, to about X-bacab, all in the state of Campeche. The slight wind was from the east, with the migration going straight against it. Where these butterflies originated, I could not guess, as all the way south to X-bacab the migration direction was straight east-

wardly. These great swarms were seen as coming from the sea, as the highway follows the shore very closely most of the way. Slightly before mid-day a great thunderstorm arose from the east, but in spite of the heavy rain, the butterflies did not stop to take shelter or rest—they just kept coming.

It is difficult to calculate the immense number that might have passed 100 meters of roadway per minute, as they formed a veritable yellow-white cloud. A conservative attempt would say there were 10,000 specimens per 10 meters of roadway, taking into account the width of the road, and the fact that the bulk of them were flying from ground level to 6–8 meters high. There were so many dead butterflies along the road, having been hit by vehicles or killed by other factors, that it looked as if it had just snowed. As I drove through the cloud of migrants I must have been killing at least 100 or more every split second; the din of their crushed bodies against my vehicle stirred remorse within me—I felt like a treacherous assassin. This migration began to thin out near X-bacab, and by the time I arrived at Escárcega, it was possible to calculate about 1000 specimens crossing 100 meters of road per minute.

When I returned through the same area about 3 July 1971, the bulk of the migration had waned. Now the strongest concentration was south of X-bacab, through Escárcega, and southwest to Pital and Río Candelaria. The numbers were about 500 per 100 meters of roadway per minute, and the direction had changed towards the southeast.

I will here add that when passing through Tamaulipas in northeast México in early June after leaving Campeche, I noticed *Kricogonia* flying westwardly, but in minimum numbers, about 1 or 2 in sight at any given moment, crossing the road at ground level.

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#### AN ALTERNATIVE CAUSE OF DIMORPHISM IN *PAPILIO* PUPAE (PAPILIONIDAE)

D. F. Owen's paper, "Pupal Colour in *Papilio demodocus* (Papilionidae) in Relation to the Seasons of the Year," (1971, J. Lepid. Soc. 25: 271–274), has prompted me to make the following observations.

The idea of seasonal variation appears to have one fatal flaw. The Rutaceae, on which *Papilio demodocus* and many other *Papilio* species with dimorphic pupae feed, are always in green leaf and leaves fall off while still green. Furthermore, a recent note by Vaidya (1971, J. Bombay Nat. Hist. Soc. 68(2): 477–478) points out that the ovipositing female of *Papilio demoleus* L. requires a visual stimulus connected with leaf colour as well as the olfactory one connected with the scent of the food-plant. In my experience females of the citrus-feeding *Papilio* species invariably lay on new growth.

Generally speaking, what may be considered as typical pupae, such as *Papilio polytes* L., *P. demoleus* L., *P. demodocus* Esp., *P. nireus* L. and many others, are dimorphic, either green or otherwise, the 'otherwise' varying from pale to dark brown, various shades of grey, etc. Specialised pupae, such as the cylindrical, dark, stick-like pupa of *Chilasa clytia* L., the flattened, green, leaf-like pupa of *Papilio dardanus* Brown, and the brown pupae of *Byasa hector* L. and *B. aristolochiae* F., with their leaf-like subdorsal projections, are monomorphic.

If the colour of the pupa is controlled genetically, it is possible that there are three genotypes, a green, a brown and an optional green or brown controlled by external

stimuli. Such a hypothesis might explain the discrepancies in the figures for various broods which fail to conform to the usual Mendelian ratios.

The 'matching' theory has never attracted me, there are far too many exceptions to be found both in pupae formed naturally in the wild and those formed in the somewhat unnatural conditions of captivity; and experiments I carried out in Calcutta with *Papilio polytes* L. and *P. demoleus* L. (Sevastopulo 1948, Proc. Roy. Entomol. Soc. London (A) 23: 93) which, although not conclusive, certainly did not support the theory. It was noted in the course of these experiments that when pupating larvae slipped through their girdles and fell, the proportion of brown to green pupae was far higher than when larvae suspended themselves and pupated successfully. This suggested that movement shortly before pupation might be the determining factor, resulting in the formation of melanin.

Recently a paper by Oldroyd (1971, Entomologist 104: 111-123) gave the interesting information that the difference in colour between green and brown pupae of *Papilio memnon* L. and others appeared to be due to the presence of melanin in the latter.

I have, therefore, put forward the suggestion that it is the amount of pre-pupational travel that determines whether a pupa will be green or brown. Such a theory would account satisfactorily for the fact that green pupae are usually found among leaves, as the larvae producing these would not have to travel far, as well as explaining the occasional brown pupa found in such situations, whilst larvae that travelled some distance would be more likely to pupate on a branch or tree trunk and would be brown. Owen's own experiment would appear to support this idea.

Other supporting examples can be quoted from non-papilionid species. Recently at Mackinnon Road in Kenya I found enormous numbers of the pupae of the pierid *Anapheis aurota* F. These were placed nose-to-tail all along bare twigs of the stripped foodplant and side-by-side all around them. In many cases earlier pupae had been used as the substrate for later ones. All these pupae were a sooty black with varying amounts of white patches, and quite unlike the usual form of pupa formed in uncrowded situations, which is very like the normal forms of pupa of the European, and probably American, species of the genus *Pieris*. There can be no doubt that these vast numbers of larvae must have interfered with each other immediately prior to pupation and the amount of wriggling must have been tremendous.

Another example is provided by the nymphalid *Aglais urticae* L. When solitary larvae pupate amongst the leaves of the foodplant, they produce a brilliant golden pupa, but when they pupate on a neighbouring fence or similar object the pupae are blackish. Poulton, who studied the question extensively (1892, Trans. Entomol. Soc. Lond., 293-487), considered that the pupal colour was determined by the light falling on the larva immediately prior to hanging up for pupation, a yellow light producing golden pupae and a blue light dark ones, and suggested in another paper, which I am not able to trace at present, that the effect of the dark colour of a number of clustered larvae immediately before pupation was the cause of the blackish pupae formed in such situations. Is it not possible that the excessive movement of such a group of suspended larvae resulted in the production of extra melanin through oxidation?

Another supporting factor is that such a hypothesis would provide a satisfactory explanation for the fact that many species of larvae, when reared in overcrowded conditions, produce a form darker than the normal, the overcrowding resulting in abnormal disturbance and subsequent movement. (Long, 1953, Trans. Roy. Entomol. Soc. Lond. 104: 543-585).

Finally, to go outside the Lepidoptera, apart from the migratory urge, the main difference between the solitary and gregarious phases in the hopper stage of locusts is the darker colour of the latter, again the result of excessive melanin.

## ABNORMALITIES AND HEREDITY

Mr. Manley's paper, "Two Mosaic Gynandromorphs of *Automeris io* (Saturniidae)," (1971, J. Lep. Soc. 25: 234-238), has, to me, a most surprising omission—he does not mention whether or not the two specimens he describes came from the same brood. Many abnormalities, spiral segmentation for example, would appear to have some hereditary basis, and Ford (1955, Moths, p. 39) quotes a case where a brood of *Hemerophila abruptaria* Thnbg. (Geometridae) contained no fewer than four gynandromorphs.

This phenomenon appears to be far more common, or far more often observed, in Great Britain than in America, to judge from reading Mr. Manley's paper. Hardly a year goes by without there being some reference to one or more cases in the various British entomological journals. Cockayne, in a paper published in the Transactions of the Entomological Society of London in 1916, illustrated no fewer than twenty-one gynandromorphs of the lycaenid *Lysandra coridon* Poda.

Reverting to my remarks on spiral segmentation, the only two cases which have come to my personal knowledge have both involved more than one individual in a brood. In one case, a brood of the nymphalid *Euxanthe wakefieldi* Ward bred by a friend, the majority of the larvae died of disease before developing the characteristic and revealing dorsal markings; out of the five or six that reached maturity, two were examples of spiral segmentation, and it is more than probable that there were other examples undetected among the larvae that died earlier. The other case was in a brood of the noctuid *Leucania irregularis* Wlk., which contained at least four examples of spiral segmentation. Unfortunately the brood, which was divided into three batches at an early stage, suffered severe casualties; two of the three batches were wiped out by virus disease when still small, and a large number of the third batch was used to provide live food for some insectivorous birds before the abnormalities were detected, so that, here again, it is more than probable that a considerably larger number of spirals were actually present in the brood.

Might I end on a note of criticism of Mr. Manley's paper. Surely it is incorrect to write (top of p. 235) "Thus cells of the male with ZZ chromosomes are expressed as yellow, while those of the female with a ZO chromosome complement are rosy brown." Would it not be more correct to state that the scales and hairs arising from cells with ZZ chromosomes are yellow and those from cells with ZO chromosomes are rosy brown? It is unfortunate that the figures are too dark to allow the pattern of the 'broken eye blotch' to be seen.

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HOST RECORDS FOR *BREPHIDIUM EXILIS* (LYCAENIDAE)

The Western Pygmy Blue, *Brephidium exilis* Boisduval, is generally recorded as feeding on Chenopodiaceae, but specific host identifications are few. Downey (1961, in Ehrlich & Ehrlich, How to Know the Butterflies) lists, "*Atriplex bracteosa* (lamb's tongue), *Chenopodium* (pigweed), *Petunia parviflora*." *Petunia* is in the Solanaceae, a most unusual group to be fed upon by a Lycaenid; one species, *P. violacea* Lindl., is recorded as toxic to various insect larvae (Shapiro 1968, Ann. Entomol. Soc. Amer. 61: 1221). This paper presents information on host plants for *B. exilis* in lowland central California; plant names are from Munz & Keck (1970, A California Flora).

## Chenopodiaceae

*Atriplex patula* L. "ssp. *hastata* (L.) Hall. & Clem." (= *A. hastata* L.).—This abundant plant of brackish marshes and moist alkaline situations is the only known host for the large population of *B. exilis* in the marshes along Suisun Slough near Fairfield, Solano Co., California. It is probably the principal host in salt marshes throughout the range of *B. exilis* and is also used locally in the interior, e.g. in the Sacramento Valley east of Woodland, Yolo Co. The larvae feed on leaves, flowers, and fruit.

*Atriplex rosea* L.—An abundant weed of dry, alkaline, usually disturbed soils throughout interior California; naturalized from Eurasia. The most frequent host of *B. exilis* throughout the Sacramento Valley. Larvae feed on buds, flowers, and fruit and can only be found near the tips of branches.

*Atriplex cordulata* Jeps.—Occasional native species of dry, compacted alkaline soils; used by *B. exilis* north of Davis, Yolo Co.

*Atriplex semibaccata* R. Br.—Occasional weed of alkaline or subsaline soils and roadsides; naturalized from Australia. Fed upon by *B. exilis* at Fairfield, Solano Co., and north and west of Davis, Yolo Co. Larvae on leaves and (especially) the female flowers.

*Suaeda fruticosa* (L.) Forsk. (= *S. moquini* Greene).—Local but often common, a perennial weed of dry alkaline and subsaline situations as at the Davis municipal landfill and along the levees at Willow Slough, Yolo Co. *B. exilis* larvae abundant on the plant, feeding on inflorescence, fruit, and upper leaves; seemingly preferring *Suaeda* to *Atriplex rosea* where the two occur together. Populations of larvae are so dense on this plant as to constitute a potentially significant threat to its seed production, at least locally.

*Brephidium exilis* has not been found feeding or ovipositing on any of the following Chenopodiaceous weeds, although all are common within its range and often in close proximity to *Atriplex* or *Suaeda* bearing many larvae: *Salsola kali* L. var. *tenuifolia* Tausch. ("Russian thistle"); *Cycloloma atriplicifolium* (Spreng.) Coult.; *Chenopodium ambrosioides* L. and its varieties *anthelminticum* (L.) Gray and *vagans* (Standl.) Howell; *C. botrys* L.; *C. californicum* Wats.; *C. album* L.; *C. murale* L. Larvae taken from *Suaeda fruticosa* accepted *Chenopodium californicum* and *C. murale* but refused *C. ambrosioides* and *C. botrys*. They also accepted *Cycloloma* and *Kochia scoparia* (L.) Schrad. One larva taken from *Atriplex rosea* accepted *C. botrys* flowers. I have not seen *B. exilis* oviposit on any species of *Chenopodium*, but have taken females hovering around *C. murale* (banks of the Sacramento River) and *C. botrys* (Cache Creek, Yolo Co.), once each. Records on *Chenopodium* may well be due to misidentification of *Atriplex rosea*, which resembles that genus strongly.

Although the Eastern Pygmy Blue, *Brephidium pseudofea* Morrison, is recorded as feeding on *Salicornia* (Downey 1961, op. cit.), *B. exilis* showed no interest in *S. virginica* L. in the Suisun marshes where extensive patches of it are near colonies of *Atriplex patula* ssp. *hastata*, and no larvae were found by sweeping.

Larvae of the Western Pygmy Blue pupate on the host plant. As many of the hosts are tumbleweeds, passive dispersal of pupae on the plants in fall and winter may be a significant factor in the colonizing ability of the insect.

## Solanaceae

*Petunia parviflora* Juss. was not available for testing, but leaves, buds, and flowers of two horticultural varieties of *P. violacea* were completely unacceptable to 23 larvae of mixed sizes taken from *Suaeda*. Although less viscid than the garden species, *P. parviflora* is glandular-puberulent and should be suspected of the same toxic properties as its congener until shown otherwise.

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AN ATTEMPTED INTERFAMILIAL MATING  
(LYCAENIDAE, NYMPHALIDAE)

Interspecific courtships and matings are seldom reported in butterflies (Downey 1962, J. Lepid. Soc. 16: 235-237). The rarity of such reports involving phenotypically similar sympatric species suggests the widespread occurrence of effective prezygotic reproductive isolating mechanisms, at least some of which may have evolved as a result of selection against deleterious hybridization (Remington 1968, Evol. Biol. 2: 321-428). Although species from widely different groups might be expected to differ in so many ways as to make courtship and mating very unlikely, it is conceivable that such taxonomically wide behavioral "mistakes" may be at least as frequent as those between sympatric congeners. The actual records are far too fragmentary to allow a conclusion one way or the other. This note reports a mistaken courtship involving representatives of two butterfly families which, however, did not result in copulation.

On 26 May 1972 a fresh male *Lycaena helloides* (Boisduval) (Lycaenidae) was seen courting a fresh female *Cynthia annabella* Field (= *Vanessa carye* auct.) (Nymphalidae) in a vacant lot at Southport, Yolo County, California. The pair was first encountered at 1357 hours. The male fluttered behind the female, which sat on a leaf just above the ground. Repeated attempts at genital contact elicited only a shuffling sideways movement in the female, which finally flew desultorily some ten feet and lit on the ground, only to be overtaken at once by the male. This sequence was repeated four times in nine minutes. The courtship was terminated when the observer's shadow was inadvertently passed over the female and she left the area. The behavior of the female *C. annabella* was in no way dissimilar to that shown by the species when being courted by its own males, but not disposed to mating. However, *C. annabella*, like most "Vanessas," seems to mate principally in the late afternoon and at dusk.

*Lycaena helloides* was abundant in the area and several unsuccessful courtships within that species were seen during the early afternoon; female *L. helloides* invariably fanned their wings intermittently in response to the activity of the male, differing in this respect from the response of the *C. annabella*. The female *annabella* approached was the only individual of its species in the field during most of the afternoon. The pheromones, if any, of neither species have been studied. The *C. annabella* was fully twice the size of an *L. helloides* female, and resembled it superficially only in general color.

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ISSIKI COLLECTION OF MICROLEPIDOPTERA TO THE  
SMITHSONIAN INSTITUTION

With considerable assistance and cooperation from the United States Department of Agriculture and the United States Forest Service, the Smithsonian Institution has recently acquired the finest collection of Japanese and Formosan Microlepidoptera ever assembled. The collection represents the lifelong effort of Professor Syuti Issiki, a renowned Japanese entomologist, who, with his famous teacher S. Matsumura, pioneered the study of Oriental Microlepidoptera.

The total size of the Issiki Collection is not unusually large, numbering 16,236 moths, but the rich representation of Eastern Palearctic and Oriental species makes the collection an extremely valuable research tool. Probably 95% of the known

Japanese microlepidopterous fauna is represented in addition to nearly all of the described Formosan species. The collection is particularly strong in the primitive families, an area in which Dr. Issiki specialized. Seventy-eight holotypes are present and nearly 200 secondary types, several of the latter having been contributed in recent years by Prof. Issiki's former students. In addition to Microlepidoptera, the order Mecoptera was also an early research interest of Dr. Issiki. As a result, his collection also contains over 1,000 specimens of this order which, likewise, exhibits excellent coverage of both Formosa and Japan.

The Formosan collection represents the only serious attempt to survey the Microlepidoptera of that country and was accumulated during Dr. Issiki's tenure as Professor of Agriculture at the Imperial University at Taipei from 1920 to 1948. Examples of this material were sent to Edward Meyrick and, thus, formed the basis of Meyrick's studies on Formosan moths. Unfortunately, the collection was considerably larger than at present but was partially destroyed due to neglect following Prof. Issiki's permanent departure to Japan in 1948. The only material known to survive of the original Formosan collection, other than those duplicates retained by specialists such as Meyrick, is the synoptic representation which Issiki was able to transport at the time of his departure. During his residence in Formosa, Prof. Issiki also collected for a brief interval in New Guinea, assembling a small but select representation of Microlepidoptera from that area.

In 1949 Dr. Issiki was appointed Professor of Agriculture at the University of Osaka Prefecture, a post he held until his retirement in 1961. It was during this period that the major portion of his Japanese material was acquired. His influence as a teacher was also impressive, as several of the present generation of Japanese microlepidopterists studied under him during this period. Dr. Issiki now resides with his family in Itō City where he still actively pursues his interests on the biology of Japanese Microlepidoptera.

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## A NEW GENERIC NAME IN MIDILINAE (PYRALIDAE)

### ***Eupastranaia* Becker, new genus**

*Pastranaia* Munroe, 1970, p. 63-64; preocc. by *Pastranaia* Orfila, 1955, p. 30-31.

The genus *Pastranaia* was erected by Orfila (1955) for a new species of Nemopteridae (Neuroptera). Unfortunately Munroe (1970) chose the same name in his excellent work "Revision of the subfamily Midilinae (Lepidoptera: Pyralidae)," for the *fenestrata* group of this subfamily.

This homonymy was communicated to Dr. Munroe who recommended that the author propose a new name and that it continue to honor Dr. J. A. Pastrana.

The author is very grateful to Dr. Munroe for recommending that he publish the new name.

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——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. Adv. Genet. 10: 165-216.

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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## TAXONOMIC SIGNIFICANCE OF REFLECTIVE PATTERNS IN THE COMPOUND EYE OF LIVE BUTTERFLIES: A SYNTHESIS OF OBSERVATIONS MADE ON SPECIES FROM JAPAN, TAIWAN, PAPUA NEW GUINEA AND AUSTRALIA

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30 Owen St., Lindfield, New South Wales 2070, Australia

During observations in the field of New South Wales, I came to notice that some Australian Lycaenidae had unusual semi-transparent and sometimes brightly coloured eyes which I had not come across before in some other parts of the world, including temperate and tropical Eurasia and America. This character could be observed only in live or recently killed butterflies. The regular occurrence of this type of eye in certain lycaenid groups strongly suggested its taxonomic usefulness. Upon extending my observation to other butterfly families, I soon realised that in such semi-transparent eyes there were usually certain reflective spots which changed their position according to the direction of observation, and that these spots were observed almost invariably in Pieridae and Nymphalidae (*s.str.*), but not in Papilionidae and Hesperidae, and variably in Satyridae, Danaidae and Lycaenidae. Moreover, the pattern of these spots also appeared to be of taxonomic significance. During the past two years I have thus accumulated records of my own observations on the superficial feature of the eye in butterfly species occurring in New South Wales and Papua New Guinea.

Meanwhile, my attention was drawn to the extensive monograph, "The Compound Eye of Lepidoptera," by Yagi and Koyama (1963). In this work the authors not only recorded the pattern of reflective spots in fresh eyes for the majority of butterfly species in Japan and many species from Taiwan, but also correlated them to the histologic structure of the ommatidium and thus clarified the optical basis of the appearance of these spots. Although they gave a number of suggestions about the

taxonomy and phylogeny of butterflies as well as other Lepidoptera families based on their studies on the compound eye of Lepidoptera at large, I feel that this extensive and important work treating the subject in depth has so far failed to have an impact on the taxonomy of butterflies.

In order to pay due tribute to the work, and to fill the lacuna of knowledge and interest in this aspect of butterfly morphology and taxonomy among lepidopterists, I wish to briefly redescribe the superficial (but not histologic) features of the butterfly eye only to the extent useful to careful field workers, on the basis of records compiled by Yagi & Koyama (1963) as well as my own observations. The material so collated covers species from Japan, Taiwan, Papua New Guinea and Australia, thus representing some of the major butterfly groups in the Palaearctic, Indo-Malayan and Australian Regions. The limitation of this character as a taxonomic criterion is the fact that the eye must be observed soon after an insect is captured, but this is certainly much less demanding than is the knowledge of foodplants and early stages for inclusion in taxonomic investigations. It is desired that, through the cooperation of field workers in various countries, patterns of live butterfly eyes will soon be recorded for the groups not included in this paper.

### General Description and Terminology

The superficial appearances of butterfly eyes may be divided into two major types. One is the eye looking totally dark; the other is the eye looking semi-transparent, lightly or brightly coloured and bearing at least one, and usually seven or more, dark spots which change their position and sometimes their shape when observed from different directions.

The first type is observed in Papilionidae and Hesperiidae in which the eye may reflect strong incident lights in the form of a hexagonal bright central area. The images of such an eye are well recorded in some photographs of butterflies taken in the field, especially those of papilionid species: *Papilio aegeus aegeus* Donovan (Deger & Eden, 1970, p. 5, fig. 4); *Papilio protenor demetrius* Cramer (Kohiyama, Takase & Fujioka, 1971, fig. 5); *Papilio demoleus sthenelus* Macleay (D'Abrera, 1971, p. 41). The hexagonal spot may be observed in the eye of dead and dried specimens, suggesting that it is mainly due to surface reflection, and thus is not the subject of this paper. In some Satyridae and most Lycaenidae, the eye looks completely dark without any hexagonal bright spot. An example may be seen in the photograph of *Jalmenus eichorni* (sic) Staudinger given on p. 3 of Deger & Eden

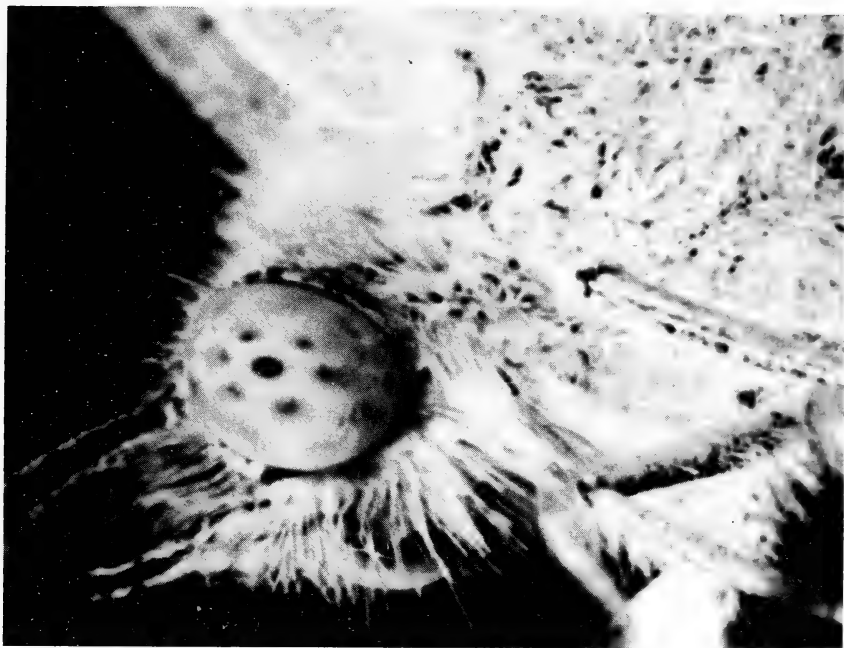


Fig. 1. A live eye of *Pieris rapae* Linnaeus, enlarged from a part of the original photograph of Deger & Eden (1970), and reproduced through the courtesy of the authors and publisher.

(1970), and of *Taraka hamada* Druce given in fig. 47 of Kohiyama et al. (1971).

A good illustration of the second type of eye may be found in the photograph of *Pieris rapae* (Linnaeus) shown in fig. 3 on p. 9 of Deger & Eden (1970), of which I reproduce a part as Fig. 1 by courtesy of these authors. As seen in the original photograph printed in colour, the eye itself is pale greenish grey with a prominent dark *central spot* which is surrounded by six conspicuous *primary side spots* arranged in a hexagonal array. Around these primary side spots, there are vague dark shadows in the form of some discrete patches, which represent the *secondary side spots*, which are rather ill-defined in this species.

These spots were called by Yagi & Koyama (1963) the "pseudopupils." The name should have been phrased the "false pupils" to conform with a uniform Latin derivation rather than a mixture of Greek and Latin ones. However, the word "pupil" even with the adjective "false" sounds inadequate because of its possible interpretational bias. The more descriptive expression "reflective spots" is being used almost as a jargon among *Drosophila* geneticists for a pair of apparently similar spots in

the eye of the wild-type individuals of *Drosophila melanogaster* Meigen. I want to borrow this expression in place of the "pseudopupil," since the latter has not yet been established among lepidopterists, and will abbreviate it as RS in the rest of this paper.

### Main Types and Subtypes of the Compound Eye

According to Yagi & Koyama (1963) the eye with RS may be divided into two major types. One has a large central spot only. In the other the central spot is smaller and usually accompanied by primary side spots which however may become very faint, and frequently by the secondary side spots which may surround strongly marked primary side spots.

The nature of the appearance of these RS has not been formulated in exact physical or mathematical terms, but is correlated by Yagi & Koyama (1963) with an at least partial absence of pigment around the distal half of the ommatidium, allowing the oblique incident light to pass through one ommatidium into another. The distribution and extent of pigmentation seem to be related to the variation of the patterns of RS, but I will not deal with this aspect here. When the butterfly dies, the appearance of RS and the semi-transparency of the eye are progressively lost hand-in-hand, suggesting a change in the refractive index of the substance filling the ommatidium. In the dark eye without RS, the ommatidia appear to be optically isolated from one another by a predominant pigmentation along the septa of each ommatidium.

In the terminology of Yagi & Koyama (1963) the dark eye without RS, the light eye having only one (large) central RS, and the light eye having basically seven or more RS were called the non-pseudopupil type, mono-pseudopupil type, and multi-pseudopupil type, respectively. In this paper I will simply call them Type I, II and III eye, respectively. If necessary, they may be called the eye with no RS, single RS and multiple RS. I have never seen a Type II eye myself and its superficial character is somewhat obscure to me. In Fig. 2 I have assembled diagrammatic representations of these three basic types, and modifications (or subtypes) of the Type III.

In the subtype IIIa, the side spots are very obscure. The primary side spots are conspicuous in IIIb; their position may be close to the central spot or to the periphery of the eye. This last example may be seen in the photograph of *Polyura pyrrhus sempronius* (Fabricius) on p. 25 of D'Abrera (1971). In IIIc, the secondary side spots are apparent. Sometimes the intensity of all the spots becomes more uniform, giving the eye a mesh-like appearance. In IIId, radial striations appear, especially around the central spot, and each RS may take a hexagonal shape. In IIIe, individual RS's take a rectangular shape and tend to be confluent.



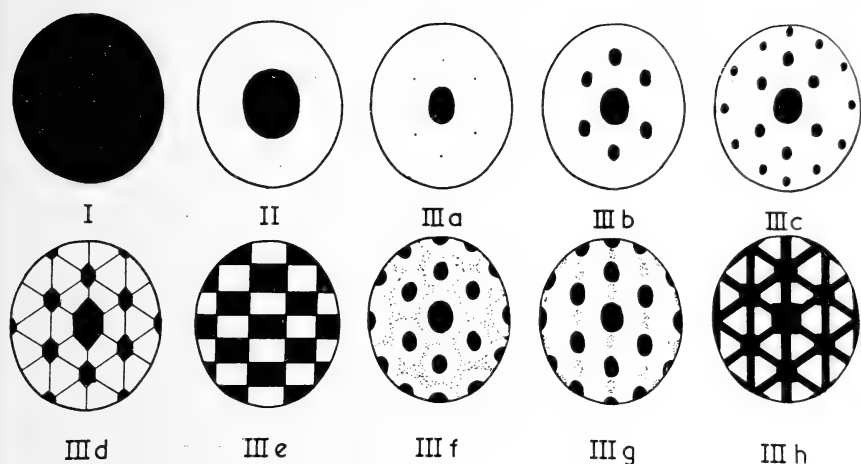


Fig. 2. Diagrammatic representation of types and subtypes of the reflective eye pattern in butterflies. Modified from Yagi & Koyama (1963) except for IIIe and h which are original, through the courtesy of Prof. N. Koyama.

III f is characterised by dark areas intercalating the RS and tending to connect one another to circumscribe the latter. III g represents a very conspicuous type in which the RS's are longitudinally united to form a striated pattern in the eye. III h is the most ill-defined pattern; here the eye looks dark and the various modifications described in III c–g seem to appear to various extents in combination.

Table 1 lists the distribution of the major types and some less frequently encountered types in each of the butterfly families<sup>1</sup> occurring in the areas covered, except for Riodinidae for which no observation has been available. Assignments of species to individual types and subtypes are compiled in the last section of this paper.

### Intraspecific Variation

Repeated observations on different individuals of the same species have given consistent results in most cases, but there does seem to be some intraspecific variation in the appearance of the live eye. The variation may fall into several categories: 1. individual variation; 2.

<sup>1</sup>The higher classification of butterflies is in a state of confusion at the moment. Almost every author seems to have his or her own system of classification. The most logical approach to the problem may be that of Ehrlich (1958) but his system has not been followed by the majority of contemporary workers in the world. There is too little room for intermediate classification in some of the Ehrlich's families which lumped together a number of distinct taxonomic groups. Here I have followed the more conventional classification for that reason. However, I admit that the standard of my recognising individual families is more arbitrary than scientific. For definition of individual families I followed Miller (1968) for Satyridae, Fox (1956) for Ithomiidae, and Eliot (pers. comm.) for Lycaenidae. Also the recent trend of splitting genera into smaller units is more (or too) conspicuous for European and Japanese fauna than Australian and New Guinean ones, and this necessarily caused unevenness in recognising individual genera.

TABLE 1. Distribution of eye types among various families of butterflies (○, common, predominant types; and ●, unusual types, in individual families).

Family	I	II	III							
			a	b	c	d	e	f	g	h
Hesperiidae	○									
Papilionidae	○									
Pieridae	●		○	○	○			●		
Danaidae	●						●		○	○
Ithomiidae				○						
Amathusiidae	○									
Satyridae	○			●	●			●	○	
Nymphalidae	●	●	○	○	○	○	●			
Acraeidae	○									
Libytheidae								○		
Lycaenidae	○		●	●	●				●	

developmental change taking place soon after emergence of the adult; 3. sexual dimorphism; 4. subspecific or seasonal difference; and 5. genetic polymorphism in one population. At the present stage of investigation it is still difficult to make a distinction in this sense among some of the observed examples of intraspecific variation. In the following I give some examples worth noting.

1. *Danaus chrysippus petilia* Stoll (Danaidae) males caught at one place (New South Wales) at the same time showed two subtypes of the Type III eye: e and h. Slight variation between a and b, b and c, or c and g may be encountered among a number of species having the Type III eye.

2. Yagi & Koyama (1963) noted that the eye of *Aporia* Hübner (Pieridae) turns from Type IIIf to Type I soon after emergence, obviously owing to a colour development around ommatidia during that period.

3. A difference in the eye pattern between the two sexes was observed in two lowland species of *Heteronympha* Wallengren (Satyridae) in New South Wales: *H. merope merope* Fabricius and *H. mirifica* Butler, in which males showed IIIb or IIIb-g eyes and females typical IIIg eyes. Another example was recognised in *Ogyris amaryllis amaryllis* Hewitson (Lycaenidae) in which males showed IIIg eyes while a single female specimen had IIIa eyes. Males of some other species of *Ogyris* Westwood have IIIg eyes like the male of *O. amaryllis*, but I have not yet examined females of these other species. My record includes a somewhat doubtful case of *Hypolimnas alimena eremita* Butler (Nymphalidae): male, IIIe; female, IIId—but this needs confirmation. In most of the observations I have made, I have not recorded the sex of the observed specimens explicitly, and it is possible that there are sexual

dimorphisms among the species recorded without reference to sex in this paper.

4. So far I have not come across any definite proof that subspecies or seasonal forms of one and the same species can differ in the reflective pattern of the eye. Nor do I know of any evidence for a genetic polymorphism related to this character among butterflies. However, in *Drosophila melanogaster* (Diptera) the somewhat similar RS's are characteristic of wild-type eyes and are absent from all the known eye-colour mutants.

### A Brief Description of the Eye Pattern in Various Taxonomic Groups and Evaluation of its Taxonomic Significance

**Hesperiidae.** All the examined species covering Coeliadinae, Pyrginae, Trapezitinae and Hesperinae have similar Type I eyes, so that this eye pattern can be regarded as an invariable character of the family. The pyrgine genus *Chaetocneme* Felder has red instead of dark brown or black eyes whose colour is stable *post mortem*. It would be of interest to know whether or not the eye of this genus follows the general pattern of the family.

**Papilionidae.** All the genera so far examined and reported, covering Parnassiinae (Zerynthiini and Parnassiini) and Papilioninae (Graphiini, Papilionini and Troidini) show Type I eyes, so that this eye pattern can be taken as a universal character of the family.

**Pieridae.** The family is characterised by the Type III eye. A remarkable exception is the genus *Aporia* Hübner having Type I eyes. Another interesting point is the appearance of IIIf eyes in *Gonepteryx* Leach and *Ixias* Hübner (Yagi & Koyama, 1963). The colour of the pierine eye ranges from greenish yellow (*Colias* Fabricius and *Eurema* Hübner) to bluish white (*Prioneris* Wallace), via the commonest pale greenish or whitish grey of most of the genera including *Catopsilia* Hübner, *Pieris* Schrank and *Delias* Hübner. The major subtypes of the eye are IIIa, b and c.

**Danaidae.** This family present certain difficult problems. Eyes of many species are dark but still usually some dark and light patterns are discernible. The diagram shown in Fig. 2 IIIh is an interpretation of the complicated pattern encountered frequently in this family. Yagi & Koyama (1963) noted that certain species of *Euploea* Fabricius in Taiwan had eyes without RS. I also noted the same with several *Euploea* species I collected in New Guinea. However, some specimens of certain species in New Guinea or New South Wales had patterns like IIIg eyes. I am not certain at the moment whether the variability of the eye pattern in this group is at least partly due to seasonal dimorphism.

TABLE 2. Distribution of Type I and III eyes among some higher taxa of Satyridae.

Taxa	Type I	Type III
BIINAE		<i>Melanitis</i>
ELYMNIIINAE		
Lethini		
<i>Lethe</i> -Series	<i>Lethe europa</i> , <i>L. chandica</i> , <i>Ninguta</i> , <i>Neope</i>	<i>Lethe marginalis</i> , <i>L. diana</i> , <i>L. sicelis</i> , <i>Harima</i>
<i>Pararge</i> -Series	<i>Lopinga</i>	<i>Lasiommata</i> , <i>Kirinia</i>
Mycalesini		<i>Mycalesis</i> , <i>Orsotriaena</i>
SATYRINAE		
Hypocystini		
<i>Hypocysta</i> -Series	<i>Hypocysta</i>	<i>Harsiesis</i> , <i>Platyphthima</i> , <i>Pieridopsis</i>
<i>Tisiphone</i> -Series*	<i>Argynnis</i> , <i>Oreixenica</i> , <i>Heteronympha penelope</i> , <i>H. paradelpha</i> , <i>H. banksii</i> , <i>H. cordace</i> , <i>Tisiphone</i>	<i>Geitoneura</i> , <i>Heteronympha merope</i> , <i>H. mirifica</i>
Coenonymphini		<i>Coenonympha</i>
Erebiini	<i>Erebia</i>	
Satyrini		
<i>Satyrus</i> -Series		<i>Minois</i>
<i>Oeneis</i> -Series	<i>Oeneis</i>	

\* Miller (1968) called this the *Xenica*-Series, but *Xenica* Westwood, 1851, is an objective synonym of *Tisiphone* Hübner, 1816–1826 (Hemming, 1967).

Working in the field it was not always possible to compare live males and females of the same species. Also the specific identification of individual specimens of *Euploea* in the field posed some problems in New Guinea. Obviously much more careful and extensive observations on many individuals are needed before something more definite can be stated about the eye of this difficult family.

**Ithomiidae.** The only known example (*Tellervo* Kirby) has sub-type IIIb eyes with a vivid yellow ground colour. The eye of this family therefore seems to be at variance with that of Danaidae or Satyridae.

**Amathusiidae.** The only known example (*Taenaris* Hübner) showed Type I eyes.

**Satyridae.** The majority of the species of this family have eyes of Type IIIg with a grey or grey-brown, but sometimes yellow, ground colour, but there occur a number of exceptions. A glance at Table 2 reveals that the difference is not apparently related to any taxonomic groupings, because both Type I and III eyes are found side by side in many recognised higher taxa, and even within a single genus, almost throughout the family. However, in most cases the eye pattern may be regarded as a good character of individual genera, especially in Hypocystini.

Also noteworthy is a consistent difference between the two sexes as exemplified by the two lowland species of *Heteronympha* (see above). One theory might be that the difference in the eye pattern is more adaptive than phylogenetic, but nothing is known about the possible correlation of certain eye types with the habitat or some other ecological or behavioral variables.

**Nymphalidae.** Most species of this family have eyes of Type III, but there is an odd example of Type I (*Clossiana thore jezoensis* Matsumura). I have a record of a live female of *Hypolimnias deois divina* Fruhstorfer having Type I eyes, while another record of mine indicates that the same species (male ?) had subtype IIIb eyes. Some species (*Dichorragia nesimachus nesiotus* Fruhstorfer and *Hestina assimilis formosana* Moore) are assigned to Type II by Yagi & Koyama (1963). Generally, the subtype IIIc predominates, but subtype IIId eyes are widely seen among members of Nymphalinae (*s.str.*). The subtype IIIa appears in Apaturinae. Many species have brightly coloured eyes: yellow or orange predominates in Argynninae; grey or brown in Nymphalinae; bluish grey in Limenitinae; light orange or yellow-brown in Apaturinae; green in some species of *Cyrestis* Boisduval, and bluish black in *Dichorragia* Butler. In Charaxinae, *Charaxes latona papuensis* Butler has bright orange eyes, while *Polyura pyrrhus sempronius* Fabricius shows Type IIIb eyes which look almost as dark as Type I eyes.

**Acraeidae.** As far as known, the eye belongs to Type I. Perhaps this character may justify the family status of this group.

**Libytheidae.** The only known case is the subtype IIIf.

**Lycaenidae.** As noted by Yagi & Koyama (1963), the majority of the species have Type I eyes. However, there are some genera with Type III eyes, which are for some unknown reason frequently met with in the Australian region. This latter type is found in various subfamilies, but its occurrence generally serves as a criterion at least for a genus, sometimes for even a higher taxon.

Thus, in Polyommatainae, *Zizula* Chapman, *Zizina* Chapman and *Zizeeria* Chapman (including the very anomalous *Z. alsulus* Herrich-Schaeffer), which are somewhat remotely related, have yellowish grey eyes of the subtype IIIa-b. *Theclinesstes* Röber and *Catopyrops* Toxopeus stand out with similar yellowish grey eyes among the genera related to *Nacaduba* Moore. Two species currently placed in *Neolucia* Waterhouse and Turner: *serpentata* Herrich-Schaeffer and *sulpitius* Miskin also have eyes similar to those of *Theclinesstes*, while *Neolucia agricola* Westwood and *N. mathewi* Miskin have Type I eyes. I have found that other features such as male genitalia and antennae of *serpentata* and *sulpitius* showed a very strong affinity to those of

*Theclinesthes* and were unlike any other groups of Lycaenidae I know of, let alone *Neolucia agricola* and *N. mathewi*. Obviously there is a need of generic rearrangement for some species hitherto placed in *Theclinesthes* and *Neolucia*, and the eye pattern is consistent with many other characters with respect to this point. Among genera allied to *Candalides* Hübner with Type I eyes, *Erina* Swainson is peculiar with Type III eyes, which seems to point to a good generic status of *Erina*.

In Theclinae, *Hypochrysops* Felder & Felder and *Philiris* Röber have yellow eyes belonging to subtype IIIa or b-g. Contrary to previous treatments by authors as recent as Common (1964), Tite (1963) or D'Abrera (1971), the two genera are taxonomically closely related as is seen from the wing shape, antennae and male genitalia. Eliot (pers. comm.) has reached the same conclusion independently. *Paralucia* Waterhouse & Turner and *Pseudodipsas* Felder & Felder have grey subtype IIIa or b-c eyes and seem to stand fairly close to the preceding two genera. More peculiar is *Ogyris* Westwood, males having characteristic Type IIIg eyes with a grey-brown ground colour, like those of many satyrid species, and the only female ever examined having subtype IIIa eyes. Two species of *Hypochlorosis* Röber in New Guinea had yellowish Type III eyes. According to a photograph shown by Kohiyama et al. (1971), *Spindasis takanonis* Matsumura may have a brown Type III eye, but this is not certain.

Curetinae seems to have disparate eye types in the single genus *Curetis* Hübner. It would be of interest to see whether or not there occur some clusters of genera having Type III eyes in areas other than the Australian region.

### Assignments of Various Species of Butterflies to Individual Types and Subtypes of the Compound Eye

Assignments taken from Yagi & Koyama (1963) are marked with an asterisk, and those inferred from the figures of Kohiyama et al. (1971) with two asterisks.

### SPECIES WITH TYPE I EYES

**Hesperiidae.** *Chaospes benjamini japonica* Murray\*; *Bibasis aquilina chrysaeglia* Butler\*; *Erynnis montanus* Bremer\*; *Daimio tethys* Ménétrière; *Trapezites eliena eliena* Hewitson, *T. iacchoides* Waterhouse, *T. phigalia phigalia* Hewitson; *Toxidia peron* Latreille; *Signeta flammeata* Butler; *Mesodina halyzia halyzia* Hewitson; *Leptalina unicolor* Bremer & Grey\*; *Aeromachus inachus* Ménétrière\*; *Isoteinon lamprospilus formosanus* Fruhstorfer\*; *Notocrypta curvifascia* C. & R. Felder\*, *N. waigensis waigensis* Plötz; *Thymelicus leoninus* Butler\*, *T. sylvaticus* Bremer\*; *Ochlodes venata herculea* Butler\*, *O. ochracea rikuchina* Butler\*; *Hesperia florinda* Butler\*; *Potanthus flavus* Murray\*; *Telicota eurasia eurychlora* Lower; *Cephrènes augiades sperthias* Felder; *Polytremis pellucida* Murray\*; *Pelopidas jansonis* Butler\*, *P. mathias oberthuri* Evans\*; *Parnara guttata* Bremer & Grey\*.

**Papilionidae.** *Parnassius eversmanni daisetsuzanus* Matsumura\*, *P. stubbendorffii hoenei* Schweitzer\*, *P. glacialis* Butler\*; *Luehdorfia puziloi inexpecta* Sheljuzhko\*, *L. japonica* Leech\*; *Pachliopta aristolochiae interpositus* Fruhstorfer\*; *Troides aeacus kaguya* Nakahara & Esaki\*; *Ornithoptera priamus richmondii* Gray; *Byasa febanus* Fruhstorfer\*, *B. polyeuctes termessus* Fruhstorfer\*, *B. alcinous* Klug\*; *Papilio machaon hippocrates* C & R. Felder\*, *P. xuthus* Linnaeus\*, *P. macilentus* Janson\*, *P. protenor amaura* Jordan\*, *P. protenor demetrius* Cramer\*, *P. memnon heromus* Fruhstorfer\*, *P. castor formosanus* Fruhstorfer\*, *P. nephelus chaonulus* Fruhstorfer\*, *P. aegeus aegeus* Donovan, *P. aegeus ormenus* Guérin, *P. ambrax ambrax* Boisduval, *P. euchenor euchenor* Guérin, *P. helenus fortunius* Fruhstorfer\*, *P. thaiwanus* Rothschild\*, *P. polytes pasikrates* Fruhstorfer\*, *P. bianor takasago* Nakahara & Esaki\*, *P. bianor dehaani* C. & R. Felder\*, *P. ulysses autolytus* Felder, *P. laglaizei* Depuiset, *P. anactus* Macleay; *Principis demoleus libanius* Fruhstorfer\*, *P. demoleus sthenelus* Macleay; *Chilasa agestor matsumurae* Fruhstorfer\*; *Graphium cloanthus kuge* Fruhstorfer\*, *G. sarpedon nipponum* Fruhstorfer\*, *G. sarpedon connectens* Fruhstorfer\*, *G. sarpedon choredon* Felder, *G. doson positonus* Fruhstorfer\*, *G. eurypylus lycaonides* Rothschild, *G. agamemnon ligatus* Rothschild, *G. wallacei wallacei* Hewitson, *G. macleayanus macleayanus* Leach, *G. weiskei* Ribbe.

**Pieridae.** *Aporia hippia japonica* Matsumura\*, *A. crataegi adherbal* Fruhstorfer\*.

**Danaidae.** *Idea leuconoë clara* Butler\*; *Euploea leucostictos hobsoni* Butler\*, *E. sylvestor swinhoi* Wallace\*, *E. tulliolus koxinga* Fruhstorfer\*.

**Amathusiidae.** *Taenaris myops kirschii* Staudinger.

**Satyridae.** *Lethe chandica rathnacri* Fruhstorfer\*, *L. europa pavida* Fruhstorfer\*; *Ninguta schrenckii menalcas* Fruhstorfer\*; *Neope goschkevitchii* Ménétries (or *N. nipponica* Butler?)\*; *Lopinga achine achinoides* Butler\*; *Hypocysta adiante adiante* Hübner, *H. pseudirius* Butler, *H. metirius* Butler, *H. aroa aroa* Bethune-Baker (? from Madang, New Guinea), *H. euphemia* Westwood; *Argynnis cyrila* Waterhouse & Lyell, *A. tasmanica* Lyell; *Heteronympha paradelpa paradelpa* Lower, *H. penelope penelope* Waterhouse, *H. banksii banksii* Leach, *H. cordace cordace* Geyer; *Oreixenica lathoniella herceus* Waterhouse & Lyell; *Tisiphone abeona abeona* Donovan; *Erebia nipponica* Janson\*, *E. ligea takanonis* Matsumura\*; *Oeneis daisetsuzana* Matsumura\*.

**Nymphalidae.** *Clossiana thore jezoensis* Matsumura\*; *Hypolimnas deois divina* Fruhstorfer ♀.

**Acraeidae.** *Acraea issoria formosana* Fruhstorfer\*; *Miyana meyeri* Kirsch.

**Lycaenidae.** *Taraka hamada* Druce\*; *Curetis brunnea* Wileman\*; *Arthopöetes pryri* Murray\*; *Ussuriana stygiana* Butler\*; *Japanica lutea* Hewitson\*, *J. saepestriata* Hewitson\*; *Shirozua jonasi* Janson\*; *Antigius attilia* Bremer\*, *A. butleri* Fenton\*; *Araragi enthea* Janson\*; *Ravenna nivea* Nire\*; *Wagimo signatus quercivorus* Staudinger\*; *Iratsume orsedice* Butler\*; *Favonius saphirinus* Staudinger\*, *F. orientalis* Murray\*, *F. yuasai* Shirozu\*, *F. cognatus* Staudinger\*, *F. jezoensis* Matsumura\*, *F. ultramarinus hayashii* Shirozu\*; *Neozephyrus taxila japonicus* Murray\*; *Chrysozephyrus smaragdinus* Bremer\*, *C. aurorinus* Oberthür (Koyama, pers. comm.). *C. ataxus kirishimaensis* Okajima\*; *Narathura japonica* Murray\*, *N. bazalus turbata* Butler\*, *N. alkisthenes* Fruhstorfer, *N. micale centra* Evans; *Jalmenus icinus* Hewitson; *Hypolycaena phorbas phorbas* Fruhstorfer, *H. danis denipha* Hewitson; *Deudorix epijarbas diovis* Hewitson; *Rapala varuna simsoni* Miskin, *R. varuna formosana* Fruhstorfer\*, *R. arata* Bremer\*; *Strymonidia w-album fentoni* Butler\*, *S. mera* Janson\*; *Ahlbergia ferrea* Butler\*; *Lycaena phlaeas daimio* Seitz; *Heliophorus ila matsumurae* Fruhstorfer\*; *Anthene lycaenoides* Felder, subsp. (New Guinea); *Holochila neuropacuna* Bethune-Baker, *H. ardosiaeca* Tite, *H. absimilis* Felder, *H. consimilis* Waterhouse; *Cyprotides cyprotus* Olliff; *Candalides xanthospilos* Hübner; *Microscene heathi heathi* Cox; *Niphanda fusca shijima* Fruhstorfer\*; *Prosotas dubiosa dubiosa* Semper, *P. nora nora* Felder, *P. nora formosana* Fruhstorfer\*, *P. papuana*

Tite, *P. felderi* Murray; *Nacaduba biocellata biocellata* Felder, *N. ruficirca* Tite, *N. kurava parma* Waterhouse & Lyell, *N. berenice* Herrich-Schäffer; *Paraduba owgarra* Bethune-Baker, *P. metriodes* Bethune-Baker; *Ionolyce helicon* Felder, subsp. (New Guinea); *Erysichton lineata meiranganus* Röber; *Neolucia agricola agricola* Westwood, *N. mathewi* Miskin; "*Castalius*" *mindarus mindarus* Felder; *Pistoria nigropunctatus nigropunctatus* Bethune-Baker; *Callictitia cyara* Bethune-Baker; *Danis hymetus taygetus* Felder, *D. hymetus hymetus* Felder, *D. albula* Grose-Smith, *D. hebes* Druce; *Pepliophorus inops piluma* Druce; *Jamides purpurata purpurata* Grose-Smith, *J. aratus* Cramer, subsp. (?), *J. nemophila electus* Grose-Smith, *J. croitus pseudoeuchylas* Strand, *J. aleuas nitidus* Tite, *J. celeno sundana* Fruhstorfer; *Catochrysops panormus papuana* Tite, *C. amasea* Waterhouse & Lyell; *Lampides boeticus* Linnaeus; *Syntarucus plinius pseudocassius* Murray; *Everes argiades hellotia Ménétriès*\*, *E. lacturnus* Hübner, subsp. (New Guinea); *Tongeia fischeri* Eversmann\*; *Pithecopis nihana urai* Bethune-Baker\*; *Celastrina argiolus ladonides* de l'Orza\*, *C. sugitanii* Matsumura\*, *C. limbata himlicon* Fruhstorfer\*, *C. albocaerulea sauteri* Fruhstorfer\*, *C. philippina nedda* Grose-Smith, *C. argioloides* Rothschild, *C. drucei drucei* Bethune-Baker, *C. leucothalia* Jordan, *C. meeki meeki* Bethune-Baker; *C. owgarra* Bethune-Baker; *Udara rona* Grose-Smith, *U. dardia owgarra* Bethune-Baker; *Eupsychellus dionisius* Boisduval; *Maculinea teleius kazamoto* Druce\*; *Sinia divina barine* Leech\*; *Euchrysops cnejus cnidus* Waterhouse & Lyell; *Plebejus argus micrargus* Butler\*; *Lycaeides argyrognomon praeterinsularis* Verity\*, *L. subsolana yagina* Strand\*, *L. subsolana yarigatakeana* Matsumura\*.

### SPECIES WITH TYPE II EYES

**Nymphalidae.** *Dichorragia nesimachus nesiotus* Fruhstorfer\*; *Hestina assimilis formosana* Moore\*.

### SPECIES WITH TYPE III EYES

Subtypes are shown in parentheses after each names wherever adequate records are available.

**Pieridae.** *Colias erate poliographus* Motschulsky (c)\*, *C. palaeno aias* Fruhstorfer (c)\*, *C. palaeno sugitanii* Esaki (c)\*; *Eurema hecabe mandarina* de l'Orza (b)\*, *E. hecabe hobsoni* Butler (b)\*, *E. laeta bethesba* Janson (b)\*, *E. esakii* Shirozu (b)\*, *E. blanda arsakia* Fruhstorfer (b)\*, *E. smilax* Donovan (b), *E. candida puella* Boisduval (b); *Catopsilia pomona* Fruhstorfer (c)\*, *C. crocale* Cramer (c), *C. pyranthe pyranthe* Linnaeus (c)\*, *C. pyranthe crokera* Macleay (b); *Gonepteryx mahaguru nipponica* Verity (f)\*; *Appias indra aristoxenus* Fruhstorfer (c)\*; *Delias nysa nysa* Fabricius (c); *Cepora nandina eunama* Fruhstorfer (c)\*, *C. perimele latilimbata* Butler (c), *C. euryxantha* Honrath (c), *C. abnormis* Wallace (c); *Elodina egnatia angulipennis* Lucas (b), *E. parthia* Hewitson (b), *E. padusa* Hewitson (a); *Prioneris thestylis formosana* Fruhstorfer (c)\*; *Ixias pyrene insignis* Butler (f)\*; *Anthocharis scolymus* Butler (c)\*, *A. cardamines ishikii* Matsumura (b)\*; *Pieris rapae rapae* Linnaeus (c), *P. rapae curcivora* Boisduval (c)\*, *P. canidia canidia* Linnaeus (c)\*, *P. melete* Ménétriès (c)\*, *P. napi nesis* Fruhstorfer (c)\*, *P. napi japonica* Shirozu (c)\*; *Leptosis nina niobe* Wallace (c)\*; *Leptidea amurensis* Ménétriès (a)\*.

**Danaidae.** *Danaus plexippus* Linnaeus (I-IIIh); *Limnas chrysippus petilia* Stoll ♂ (g-h, e), ♀ (d or e-h); *Tirumala hamata septentrionis* Butler (g)\*; *Radena similis similis* Linnaeus (g)\*; *Parantica aglea maghaba* Fruhstorfer (g)\*, *P. melaneus swinhoei* Moore (g)\*, *P. sita nipponica* Moore (g)\*, (h?)\*\*, *Euploea althaea juvia* Fruhstorfer (h?)\*, *E. mulciber barsine* Fruhstorfer (h?), *E. core corinna* Macleay ♀ (g).

**Ithomiidae.** *Tellervo zoilus hemsal* Fruhstorfer (b).

**Satyridae.** *PentHEMA formosanus* Rothschild (b?); *Melanitis leda leda* Linnaeus (f)\*, *M. leda destitans* Fruhstorfer (g), *M. phedima oitensis* Matsumura (f)\*, *M.*



*phedima polishana* Fruhstorfer (f)\*, *M. amabilis* Boisduval subsp. (New Guinea) (g); *Mycalesis gotama fulginia* Fruhstorfer (g)\*, *M. francisca formosana* Fruhstorfer (g)\*, *M. terminus kyllenion* Fruhstorfer (g); *Lethe marginalis* Motschulsky (g)\*, *L. diana* Butler (g)\*, *L. sicelis* Hewitson (g)\*; *Harima callipteris* Butler (b-c)\*; *Kirinia epaminondas* Staudinger (g)\*; *Lasiommata deidamia interrupta* Fruhstorfer (g)\*; *Harsiesis hygea hygea* Hewitson (g); *Pieridopsis virgo* Rothschild & Jordan (g); *Platypthima homochroa* Rothschild & Jordan (g), *P. decolor* Rothschild & Jordan (g); *Geitoneura klugi klugi* Guérin (b), *G. acantha acantha* Donovan ♀ (b-g); *Heteronympha merope merope* Fabricius ♂ (b), ♀ (g), *H. mirifica* Butler ♂ (b-g), ♀ (g); *Ypthima arctous papuana* Fruhstorfer (g), *Y. arctous arctous* Fabricius (g), *Y. argus* Butler (g)\*, *Y. yamanakai* Sonan (g)\*, *Y. multistriata* Butler (g)\*, *Y. esakii* Shirozu (g)\*; *Coenonympha oedippus annulifer* Butler (g)\*; *Minois dryas bipunctatus* Motschulsky (g)\*.

**Nymphalidae.** *Cupha prosopoe oderca* Fruhstorfer (b); *Mellicta ambigua niphona* Butler (b)\*; *Melitaea scotosia* Butler\*; *Clossiana freija asahidakeana* Matsumura (b-c)\*; *Brenthis daphne rabdia* Butler (c)\*, *B. ino tigroides* Fruhstorfer (c)\*; *Argynnis paphia geisha* Hemming (c)\*, *A. anadyomene midas* Butler (c)\*; *Damora sagana liane* Fruhstorfer (c)\*; *Fabriciana adippe pallescens* Butler (c)\*, *F. nerippe* C. & R. Felder (c)\*; *Mesoacidalia charlotta fortuna* Janson (c)\*; *Argyronome laodice japonica* Ménétriers (c)\*, *A. rulsana lysippe* Janson (c); *Argyreus hyperbius hyperbius* Linnaeus (c)\*, *A. hyperbius inconstans* Butler (b); *Vindula arsinoe rebeli* Fruhstorfer (c); *Vagrans egista offaka* Fruhstorfer (c-d); *Araschnia burejana strigosa* Butler (b)\*, *A. levana obscura* Fenton (b)\*; *Polygonia c-aureum* Linnaeus (d)\*; *P. c-album hamigera* Butler (d)\*, *P. vau-album samurai* Fruhstorfer (d)\*; *Kaniska canace no-japonicum* von Siebold (d)\*, *K. canace drillon* Fruhstorfer (d)\*; *Nymphalis antiopa asopos* Fruhstorfer (d)\*, *N. xanthomelas japonica* Stichel (d)\*; *Inachis io geisha* Stichel (d)\*; *Aglais connexa* Butler (d)\*; *Cynthia cardui* Linnaeus (c)\*; *Vanessa indica* Herbst (e)\*; *Precis almana almana* Linnaeus\*, *P. lemonias lemonias* Linnaeus\*, *P. iphita iphita* Cramer\*, *P. erigone tristis* Miskin (b); *Yoma algina etonia* Fruhstorfer (c); *Symbrenthia hippocle formosana* Fruhstorfer\*, *S. hippocle hippocrates* Staudinger; *Hypolimnias missippus* Linnaeus (RS round and H-shaped)\*, *H. bolina* Linnaeus\*, *H. bolina nerina* Fabricius (e), *H. alimena eremita* Butler ♂ (e), ♀ (d), *H. deois divina* Fruhstorfer (b); *Doleschallia bisaltide guralca* Grose-Smith (c); *Kallima inachus formosana* Fruhstorfer\*; *Mynes geoffroyi ogulina* Fruhstorfer (b); *Cyrestis achates achates* Butler (b), *C. thyodamas mabella* Fruhstorfer\*; *Phacodyma shepherdii damia* Fruhstorfer (b); *Neptis praslini meridionalis* Talbot (b), *N. sappho intermedia* Pryer (c)\*, *N. hylas luculenta* Fruhstorfer\*, *N. nata lutatia* Fruhstorfer\*, *N. philyra excellens* Butler\*, *N. rivularis insularum* Fruhstorfer\*, *N. pryleri jucundita* Fruhstorfer\*, *N. alwina kaempferi* de l'Orza\*; *Athyma selenophora laela* Fruhstorfer (b-d)\*, *A. perius perius* Linnaeus\*; *Ladoga camilla japonica* Ménétriers (b-d)\*, *L. glorifica* Fruhstorfer (b-d)\*; *Helcyra chionippe thyiada* Fruhstorfer (c); *Apatura ilia substituta* Butler (a-b)\*; *Hestina japonica* C. & R. Felder (a-b)\*; *Sasakia charonda* Hewitson (a-b)\*; *Charaxes latona papuensis* Butler (c); *Polyura pyrrhus sempronius* Fabricius (I-IIIb).

**Libytheidae.** *Libythea celtis celtoides* Fruhstorfer (f)\*, *L. celtis formosana* Fruhstorfer (f)\*.

**Lycaenidae.** *Curetis acuta paracuta* de Niceville (a)\*; *Paralucia aurifer* Blanchard ♂ (b-c), *P. aenea aenea* Miskin ♂ (b-c); *Pseudodipsas brisbanensis brisbanensis* Miskin ♂ (b), *P. cuprea* Sands ♂ (a); *Hypochrysops delicia delicia* Hewitson ♂ (b), *H. ignita ignita* Leach ♂ (a), *H. cyane* Waterhouse & Lyell ♂ (b-g), *H. epicurus* Miskin, *H. byzos* Boisduval, *H. pythias pythias* Felder ♂ (b), *H. rufinus* Grose-Smith ♀ (b), *H. polycletus rex* Boisduval (b-g); *H. argyriorufa* van Eecke ♂ (a), *H. chrysargyra* Grose-Smith ♂ (b-g); *Phylliris innotatus* Miskin ♂, *P. albi-humerata* Tite ♂ (a), *P. unipunctata* Bethune-Baker ♂ (a), *P. griseldis griseldis* Staudinger (b), *P. moira moira* Grose-Smith (b); *Ogyris gamarea gela* Waterhouse

♂ (g), *O. ianthis* Waterhouse ♂ (g), *O. abrota* Westwood ♂ (g), *O. amaryllis amaryllis* Hewitson ♂ (g), ♀ (a); *Hypochlorosis lorquini metilia* Fruhstorfer (a), *H. humboldti* Druce (a); *Spindasis takanonis* Matsumura ?\*\*; *Erina acastra* Cox ♂ (a), *E. hyacinthina hyacinthina* Semper ♂ (a); *Catopyrops ancyra mysia* Waterhouse & Lyell ♂ (a-b), *C. florinda estrella* Waterhouse & Lyell ♂ (a-b); *Theclinesthes miskini* Lucas ♂ (a), *T. onycha onycha* Hewitson ♂ (a-b); "*Neolucia*" *sulpitius sulpitius* Miskin (a), "*N.*" *serpentata serpentata* Herrich-Schäffer (a); *Zizeeria maha argia* Ménétriers (b)\*, *Z. maha okinawana* Matsumura (a)\*, *Z. knysna karsandra* Moore (a), "*Z.*" *alsulus alsulus* Herrich-Schäffer (a); *Zizina otis aruensis* Swinhoe (a); *Zizula hylax dampierensis* Rothschild (a).

### SUMMARY

The observations of Yagi & Koyama (1963) on the superficial reflective pattern of fresh compound eyes based on butterflies from Japan and Taiwan are extended to those from Papua New Guinea and Australia. Three basic patterns of the eye are recognised: Type I, with no reflective spots (RS); Type II, with single RS; and Type III, with multiple RS. The last one is divided into several subtypes according to the number, shape, distribution and modification of RS. A number of higher taxa may be well characterised by the eye patterns. Records of assignments of individual species to various eye types are compiled.

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STUDIES ON THE *CATOCALA* (NOCTUIDAE) OF SOUTHERN  
NEW ENGLAND. IV. A PRELIMINARY ANALYSIS OF  
BEAK-DAMAGED SPECIMENS, WITH DISCUSSION OF  
ANOMALY AS A POTENTIAL ANTI-PREDATOR FUNCTION  
OF HINDWING DIVERSITY

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An intensive study of the biology of the *Catocala* moths is presently being conducted in southern New England (Sargent & Hessel, 1970; Kellogg & Sargent, 1972; Sargent, 1972a). During the course of these investigations, substantial numbers of beak-damaged specimens have been collected. The present study was undertaken in hopes that an analysis of such specimens might shed some light on various aspects of the predator-prey relationships involving birds and these moths.

Prior Studies

Beak-damaged Lepidoptera have attracted considerable attention in the literature, though most prior studies have been concerned almost

exclusively with butterfly examples. A number of interpretations of various damage patterns have been advanced, and some of these seem generally accepted. Thus, V-shaped tears in the wings, which suggest that the specimens involved have torn free from bird attacks, have been regarded as evidence of palatability in their bearers. On the other hand, disabling injuries (i.e. those sufficient to prevent flight) have been regarded as evidence that their bearers are unpalatable or otherwise noxious (e.g. Poulton, 1913). Unpalatability has also been advanced as an explanation for crisp beak-imprints on the wings, the presumption being that specimens exhibiting such marks have been purposely released by birds (e.g. Collenette & Talbot, 1928). This last explanation receives support from studies showing a relatively high frequency of crisp beak-imprints on the wings of aposematic species (e.g. Carpenter, 1941). Beak-damage patterns have also provided evidence that the small, eye-spot markings on the margins of butterfly wings direct the attacks of birds (e.g. Marshall & Poulton, 1902; Swynnerton, 1926; Blest, 1957), and so function as deflective devices.

Although beak-damage patterns in moths have received little attention, the prior work with butterflies encouraged the present study and raised hopes that some insight could be gained into predator-prey relationships involving the *Catocala* moths.

### Anti-Predator Functions of *Catocala* Wings

*Catocala* moths appear to rely upon the bark-like crypsis of their forewings as their primary defense against predation. A number of studies reveal the extent to which this crypsis is enhanced by means of behavioral adaptations, e.g. the selection of appropriate backgrounds (Sargent, 1966, 1968, 1969a, 1973; Keiper, 1968; Sargent & Keiper, 1969), and the adoption of appropriate resting attitudes (Sargent, 1969b). It seems likely that forewing variations, particularly the dramatic polymorphisms exhibited by many species, function to augment the effectiveness of crypsis by foiling predator tendencies to form "specific searching images" (Tinbergen, 1960) for particular cryptic patterns (Sargent, 1972b).

Hindwing function in *Catocala* moths has not been extensively studied. It is generally assumed that these boldly patterned, and often colorful, structures are examples of "flash coloration," being revealed when crypsis fails to deter attack and a moth takes flight, only to be concealed when the moth again alights. Such "flash and cover" sequences are presumed to confuse predators as to the whereabouts of the moths (Cott, 1940; Ford, 1967).

It is sometimes assumed that the flash of the hindwings is itself the important anti-predator device, functioning to startle predators and

thereby adversely affecting the efficiency of their attacks. In this event, *Catocala* hindwings would have a function similar to that suggested for the large eye-spots of saturniid moths (Blest, 1957; Coppinger, 1970).

*Catocala* hindwings might also serve a deflective function. In this case, predators would direct their attacks toward these prominent structures, thereby being directed away from more vulnerable body parts. *Catocala* hindwing patterns would then be functionally related to the small eye-spots found along the margins of some butterfly wings, which are known to direct predator attacks (Poulton, 1890; Blest, 1957).

The interspecific diversity found in hindwing colors and patterns in the genus *Catocala* has also been suggested as an anti-predator adaptation (Sargent, 1969c). In this view, hindwing variation introduces the potential of novelty (unfamiliar stimuli) or anomaly (unexpected stimuli) as a startle mechanism into predator-prey relationships involving birds and several *Catocala* species. For example, a bird, after several successive encounters with species possessing a particular hindwing pattern (e.g. yellow and black bands), might become habituated to that pattern; but this same bird, upon encountering a distinctly different hindwing pattern (e.g. pink and black bands), might be effectively startled. If the level of startle exhibited by a bird to a particular hindwing pattern were a function of the extent and recency of its experience with that pattern, then considerable advantage might accrue to an assemblage of rather similar cryptic species which evolved a variety of hindwing patterns (see discussion of schizomimicry; Sargent, 1969c).

While it appears likely that *Catocala* hindwings serve one or more of the preceding anti-predator functions, it is also quite possible that they play an important role in other aspects of the biology of these moths. The rather surprising lack of intraspecific hindwing variation in the genus suggests that these structures may function as releasers and anti-hybridization devices in courtship and mating behaviors. Little is known of these behaviors, but in one species, *C. relictæ* Walker, mating can occur under conditions of essentially complete darkness (Sargent, 1972a). However, until much more is known of *Catocala* courtship and mating behaviors, the question of a sexual role for the hindwings must remain open.

#### METHODS

The primary aims of the present study were to describe and interpret the beak-damage patterns found on the wings of wild-caught *Catocala* moths. In order to achieve these aims, two procedures were followed: (1) recording the behavioral interactions between captive birds and *Catocala* moths in aviaries, and collecting those moths which escaped

under these circumstances for later analysis of their beak-damage patterns; and (2) collecting all *Catocala* specimens showing suspected beak-damage from a large field sample being obtained in connection with other studies.

### Aviary Study

The *Catocala* used in this study were 50 fresh, undamaged specimens which were taken in a Robinson trap in Leverett, Massachusetts during July and August of 1971. These moths were released to birds in two aviaries (each  $8 \times 5 \times 10$  ft.) which were located on the roof of the Morrill Science Center on the University of Massachusetts (Amherst) campus. The aviaries were lined with fine-mesh hardware cloth which prevented escape of the moths.

Each aviary housed seven blue jays (*Cyanocitta cristata*) which were 1-2 years old, and which had been hand-reared from approximately 14 days of age by Dr. Alan C. Kamil and his graduate students in the Psychology department. These birds had been tested in discrimination and learning-set experiments (e.g. Hunter & Kamil, 1971), but their prior experience with insects was limited to the mealworms (*Tenebrio* larvae) which were used as reinforcements in these experiments, and to various flies, etc. which frequented their aviaries. The birds were normally maintained on a free-feeding schedule of food (mynah pellets) and water, but prior to the release of *Catocala* into the aviaries, the food was withdrawn for a period of 16-24 hours. Under these circumstances, the moths were quickly attacked by the birds.

The observations of moth-bird interactions included careful attention to such matters as: (1) whether a moth was attacked while flying or resting; (2) if attacked while resting, the direction from which attack occurred (rear, side, etc.); and (3) if escaping from attack, the duration of retention in the bird's beak (instantaneous, several seconds, etc.).

Of the 50 *Catocala* specimens released to the birds, 23 were recovered for analysis of their beak-damage patterns. Every effort was made to recover each moth which escaped its initial attack, but some specimens suffered second or third attacks before they could be captured. The birds became progressively more efficient at taking the moths, losing 10 of the first 12 released, but successfully capturing each of the last 15 specimens. Moths that were eaten by the birds were initially ingested wings and all, but after some experience the birds invariably attempted to remove the wings by holding the moths in their feet and pecking with their beaks. None of the birds developed the clean, efficient shearing-off of the wings, without use of the feet, that I have witnessed in blue jays in the field.



- a. apex of beak-imprint directed toward (but not across) inner margin of forewing; unilateral (Figs. 3a; 6a,b; 7a,b)
- b. apex of beak-imprint directed toward (and across) costal margin of forewing; unilateral or bilateral (Figs. 3b; 6c)
- c. apex of beak-imprint directed toward (and across) inner margin of forewing; bilateral (Figs. 3c; 6d)

This classification of beak-damage patterns, based on specimens obtained in the aviary study, also proved adequate for classifying the field sample specimens. The number of examples of each damage pattern obtained in both the aviary and field samples is given in Table 1. Note that a number of specimens (6 in the aviary sample, 8 in the field sample) exhibited two damage patterns (e.g. Fig. 7).

Most of the field specimens were easily assigned to categories within the preceding classification, but occasional difficulties were encountered. For example, three specimens were apparently grasped from the rear while resting such that the apex of the bird's beak almost, but not quite, reached the forewing costa. The resulting damage, which technically had to be classified as Type IIa, included at least a portion of a crisp beak-imprint, and this is a characteristic of Type III damage. Another problem was posed by four specimens which exhibited smeared, rather than crisp, beak-imprints. However, since these specimens otherwise met the criteria of Type III damage, they were so classified.

The only damage pattern which was not obtained in the field sample

TABLE 1. Distribution of damage patterns among *Catocala* in the aviary and field samples.

Damage Patterns		Number of Individual Examples	
		Aviary Sample	Field Sample
Type I	a	12	33
	b	1	1
Type II	a	5	16
	b	2	3
	c	1	2
Type III	a	5	13
	b	2	5
	c	1	0
Totals		29	73



## I.

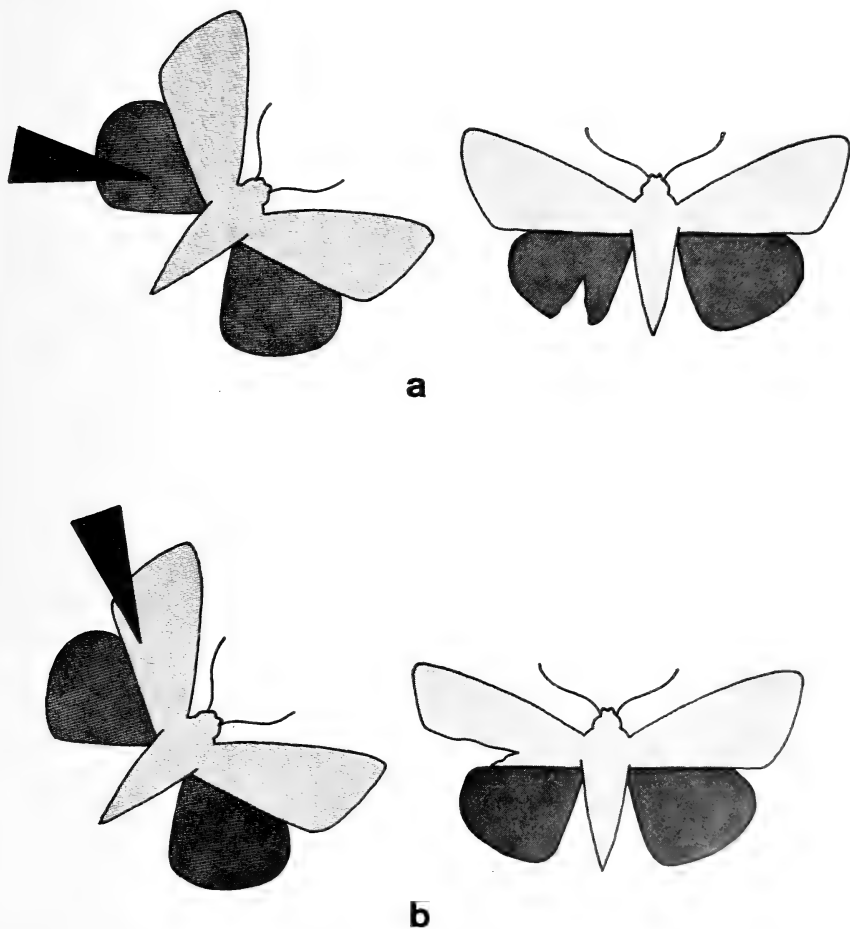


Fig. 1. Type I damage patterns. Diagrammatic representations of bird attacks on flying moths (left), and the resulting specimens (right). Damage is usually confined to one hindwing (a), rarely to one forewing (b).

was Type IIIc. The attack which leads to this damage pattern (Fig. 3e) was the one that blue jays in the aviaries used almost exclusively after they had had some experience with *Catocala*. A moth grasped in this fashion rarely escaped, as its wings were securely held in place. However, on one occasion a bird apparently loosened its grip when attempting to transfer a moth from its beak to its feet, and the escaped specimen was recovered (Fig. 6d). Presumably such "carelessness" would be very rare in nature.

## II.

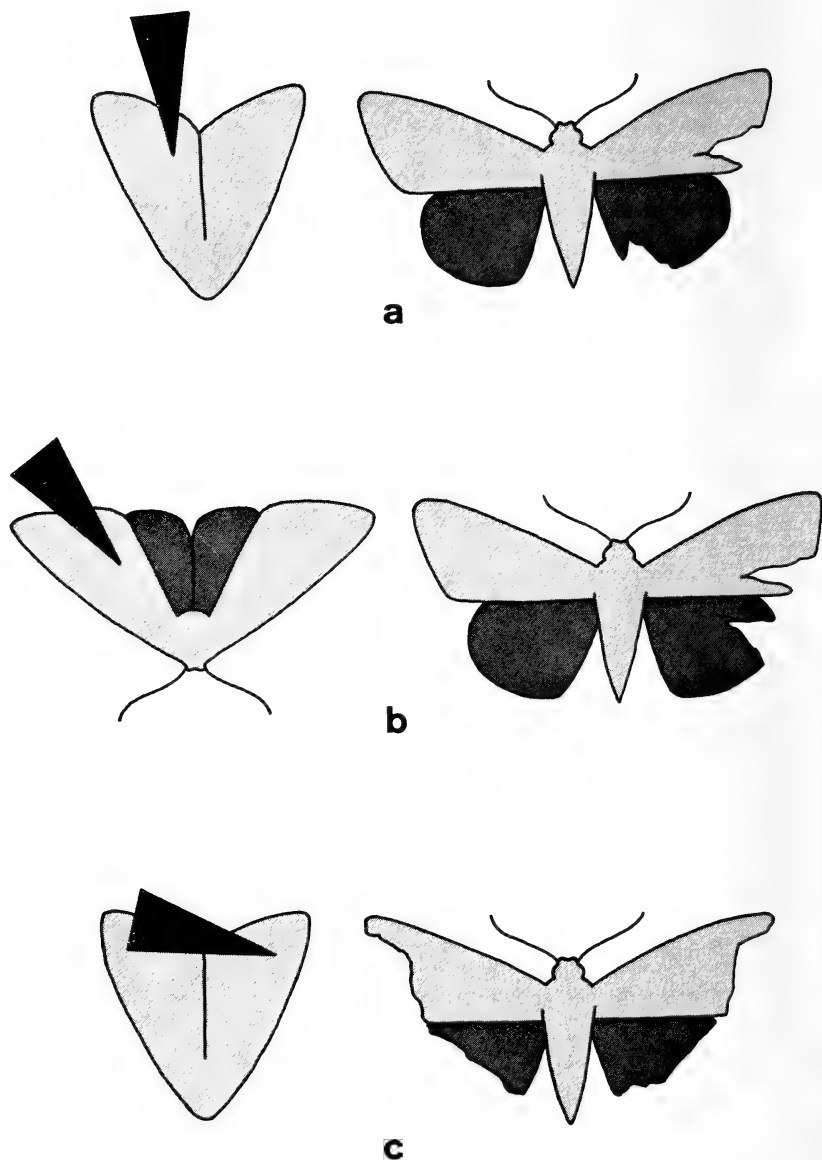


Fig. 2. Type II damage patterns. Diagrammatic representations of bird attacks on resting moths (left), and the resulting specimens (right). Damage may be inflicted when the wings are fully closed (a) or partially spread (b), and while usually unilateral, may be bilateral (c) on occasion.

III.

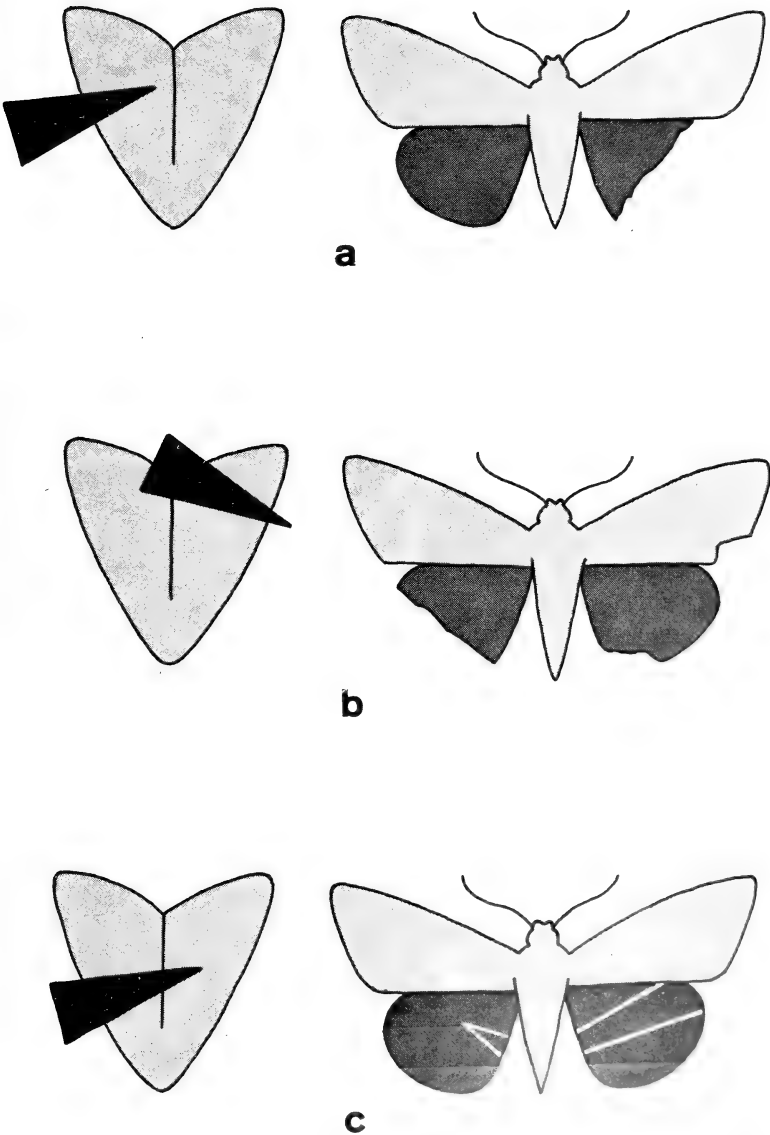


Fig. 3. Type III damage patterns. Diagrammatic representations of bird attacks on resting moths (left), and the resulting specimens (right). The beak-mark is usually confined to one forewing, including an imprint of the apex (a) or not (b), but may extend across both forewings (c).

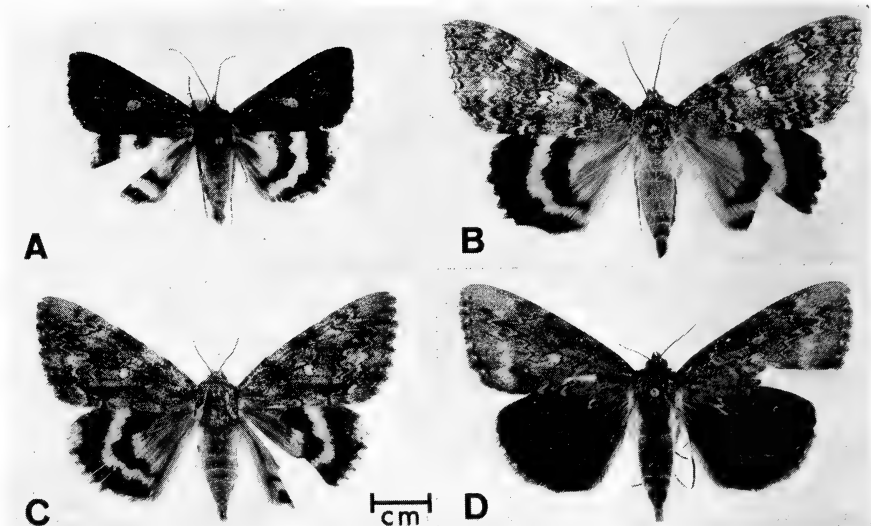


Fig. 4. Specimens exhibiting Type I damage patterns: **A.** *C. antinympha*, Ia (8 August 1970, Leverett, Mass., Robinson trap); **B.** *C. unijuga*, Ia (30 August 1971, Leverett, Mass., bait); **C.** *C. palaeogama*, Ia (28 August 1971, Leverett, Mass., Robinson trap); **D.** *C. residua*, Ib (8 July 1972, Fontana, No. Carolina, black light—specimen courtesy D. F. Schweitzer).

As mentioned previously, a number of specimens which were initially retained in the field sample were later judged to be bat-damaged rather than bird-damaged. On one occasion a moth was observed to escape a bat attack near the Robinson trap, and this specimen was immediately recovered (Fig. 8b). Other specimens exhibiting the same distinctively frazzled or tattered outer wing margins (e.g. Fig. 8a) were presumed to be bat-damaged as well.

TABLE 2. Distribution of damage patterns among field-caught *Catocala* of two hindwing types.

Hindwing Types	Number of Individual Examples			Total Sample
	Damage Patterns			
	I	II	III	
Chromatic	28	14	10	1228
Achromatic	6	7	8	395
Percent Achromatic	17.6	33.3	44.4	24.3

Note: The achromatic hindwing totals include one specimen of *C. relictia* (banded, as opposed to uniformly black, upper hindwing surface) under damage patterns I and III, and there were 28 specimens of this species in the total sample.

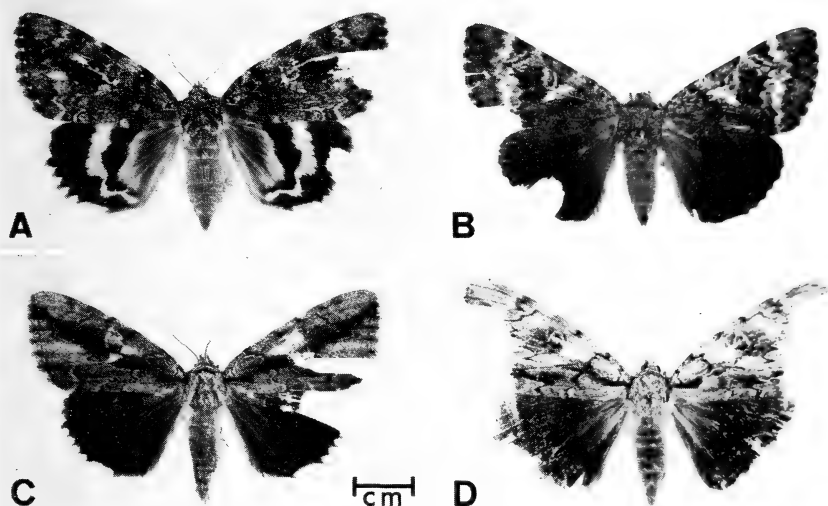


Fig. 5. Specimens exhibiting Type II damage patterns: **A.** *C. ilia*, IIa (5 August 1971, bait); **B.** *C. epione*, IIa (10 August 1971, black light); **C.** *C. flebilis*, IIb (4 September 1971, Robinson trap); **D.** *C. resecta*, IIc (12 September 1971, Robinson trap). All specimens from Leverett, Mass.

It seemed of some interest to ascertain whether the various types of beak-damage were distributed in the same way among moths having very different types of hindwings. Accordingly, the major beak-damage patterns were tabulated separately for moths having chromatic and achromatic hindwings (Table 2). (Chromatic hindwings include those characterized by color, this color generally providing a ground for prominent black bands on both the upper and lower wing surfaces. Achromatic hindwings include those characterized by the absence of color, with the upper wing surface generally solid black, and the lower wing surface banded with black and white. Both hindwing types may have a more-or-less prominent white fringe.)

Analysis of the data in Table 2 revealed that significantly more specimens with achromatic hindwings were found with Types II and III damage (escaping attacks while resting) than were found with Type I damage (escaping attacks while flying), or than were present in the total field sample (chi-square  $2 \times 2$  contingency tests:  $P$ 's  $< 0.05$ ).

#### DISCUSSION

In the present sample of wild-caught *Catocala* moths, 4% of the individuals exhibited clear evidence of at least one bird attack. These collected moths had successfully escaped their attackers, but it may be

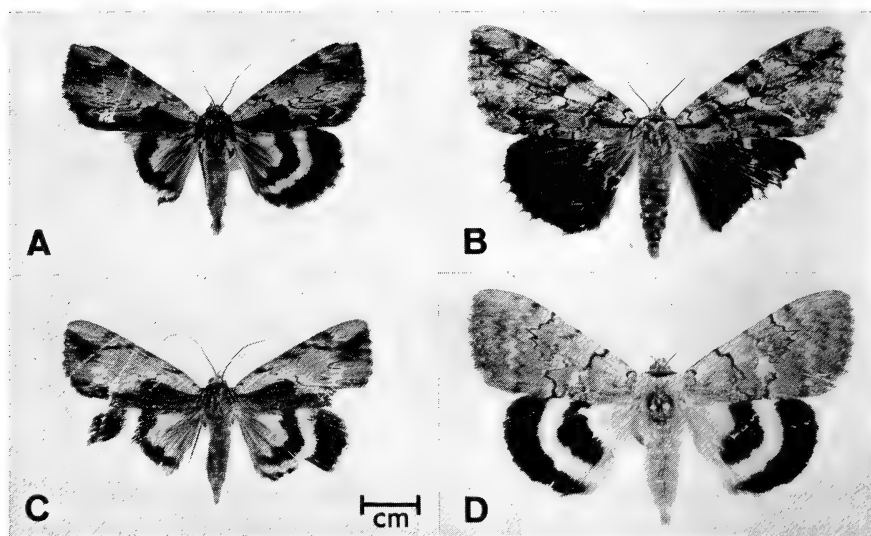


Fig. 6. Specimens exhibiting Type III damage patterns: **A.** *C. ultronia*, IIIa (experimental moth 2); **B.** *C. resecta*, IIIa (experimental moth 6); **C.** *C. ultronia*, IIIb (11 August 1970, Robinson trap); **D.** *C. concumbens*, IIIc (experimental moth 10). All specimens from Leverett, Mass.

assumed that many other individuals were not so successful. Thus it appears that avian predation on *Catocala* moths is substantial. In such a circumstance, one would expect the prey to have some highly evolved defensive strategies. The bark-like crypsis of *Catocala* forewings, coupled with appropriate behaviors, seems a clear example of such a strategy. The anti-predator functions of *Catocala* hindwings have not been clearly established, but an analysis of the present beak-damaged specimens provides evidence for both deflective and startle functions.

Nearly half of the beak-damaged specimens were apparently attacked while in flight, and all but one of these exhibited only hindwing damage. It appears that bird attacks are frequently directed towards these structures when *Catocala* moths are flying, and that such attacks may result in damage which is not highly detrimental to the moths (some specimens have been taken at lights which are missing virtually all of one hindwing). Thus *Catocala* hindwings apparently function on some occasions in a fashion similar to the colorful, but expendable, tails of certain lizards (Cott, 1940).

The remaining half of the beak-damaged specimens were apparently attacked while resting. Escape from these attacks seemed to be of two sorts: (1) a pulling-free of the moth *while* being tightly gripped by a bird, resulting in a tearing of the wings around the region of beak con-



Fig. 7. Specimens exhibiting two damage patterns: **A.** *C. ultronia*, IIIa on the left side, Ia on the right side (11 August 1971, black light); **B.** *C. ultronia*, IIb on the left side, IIIa on the right side (19 August 1971, Robinson trap). Both specimens from Leverett, Mass.

tact (Type II damage); and (2), a release of the moth *after* being tightly gripped by a bird, resulting in a clear beak-imprint along some of the lines of beak contact (Type III damage). Escapes of the first sort apparently occurred when the size, speed, and strength of the moth enabled it to break free from the grip of a bird. It is postulated that escapes of the second sort were at least in part a result of startle responses of the predators to the sudden appearance of the contralateral hindwing (i.e. opposite the side being gripped). The startle response is viewed as effecting a momentary relaxation of a bird's grip, this relaxation enabling the moth to make its escape, and leaving a crisp beak-imprint on some part of its wings. (It seems likely that some of the specimens exhibiting Type II damage could have startled their predators, but that tears normally occurred in the wings, rather than beak-imprints, because a bird's grip in such cases included only the more fragile portions of the forewing. Thus, the normal swift escape reactions of the moths might have resulted in significant tearing of the wings before

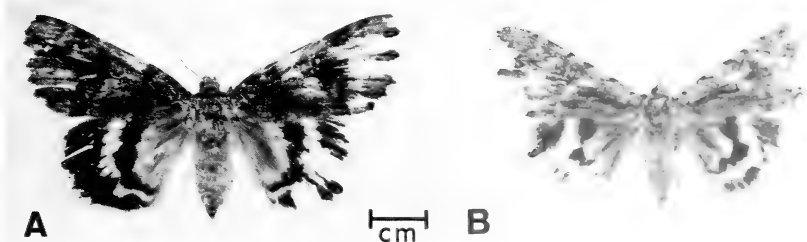


Fig. 8. Specimens exhibiting bat-inflicted damage: **A.** *C. ilia* (8 August 1971 bait); **B.** *C. habilis* (18 September 1971, Robinson trap). Both specimens from Leverett, Mass.

the birds relaxed their grip, with further tearing perhaps resulting from subsequent wear on the wings.)

There appears to be a contradiction between the functions of deflection and startle for the same structures with respect to the same predators. However, the resolution of this apparent contradiction may lie in an understanding of the nature of startle in this situation. It is suggested that the degree of startle exhibited by a bird in any encounter with a *Catocala* hindwing pattern is not so closely related to that hindwing pattern per se, as it is to the degree of expectation of that pattern which the bird brings to the encounter on the basis of its past experience. Thus, *anomaly*, defined in terms of departure from expectation, is regarded as the critical factor in determining whether a bird will react by releasing a *Catocala* moth which suddenly displays a particular hindwing pattern. This instantaneous reaction might not interfere in any substantial way with the ability of a bird to attack a flying moth, when time to adjust to the appearance of the hindwings might be available.

An "anomalous stimulus" (defined in terms of its departure from expectation and the momentary startle it elicits) would be clearly distinguishable from a "frightening stimulus" (which is usually defined in terms of its absolute properties and the innate rejection it elicits), and could often be distinguished from a "novel stimulus" (which is usually defined in terms of its unfamiliarity and the avoidance it elicits) (see Brower, 1971). Anomaly and novelty are obviously closely related, and although an anomalous stimulus need not be a novel stimulus (as these are here defined), the two phenomena may produce similar physiological effects in predators (e.g. high arousal (Coppinger, 1970), or an "orienting reflex" (Sokolov, 1960)).

The primary evidence that *Catocala* hindwings function as anomalous stimuli is provided by the specimens which exhibit crisp beak-imprints on their wings (Type III damage). Such beak-marks on lepidopteran wings have long been regarded as evidence that the specimens involved were captured and subsequently released by birds. Since beak-marks of this sort are most often found on aposematic species, it has been assumed that release of the specimens followed predator recognition of some noxious quality (usually odor or taste) of the captured prey. However, *Catocala* moths, as far as is known, are entirely palatable (many species are readily eaten by cage-birds (pers. obs.), and the work of Jones (1932) supports the assumption of their palatability). Why should these moths be released after capture by birds?

The answer to this question may be related to some sort of startle response on the part of predators, and it is suggested that interspecific hindwing variation provides the key to understanding the situation. This



hindwing variation introduces the potential of anomalous stimuli into predator-prey relationships involving these moths. Thus, a predator is seen as building up expectations regarding future hindwing patterns on the basis of its past experiences with these patterns, reacting more and more efficiently if these expectations are met, but inefficiently if they are countered. Inefficiency presumably results from some involuntary response (e.g. gaping) which is elicited by an unexpected stimulus, and which interferes with the completion of normal attack, allowing a moth to escape.

Some indirect evidence for this view is provided by an analysis of the distribution of beak-damage patterns on moths having different hindwing types. The most obvious discontinuity among *Catocala* hindwings occurs between the chromatic and achromatic patterns. As individuals possessing chromatic hindwings are more common than those possessing achromatic hindwings (the latter comprising less than 25% of the *Catocala* taken in Leverett each year), it might be predicted that achromatic hindwings would be less often encountered, and therefore more often anomalous, than chromatic hindwings. Analysis of the data in Table 2 reveals that beak-damage patterns II and III are more commonly found on individuals possessing achromatic hindwings than would be expected on the basis of chance. This finding suggests that achromatic hindwings are particularly effective as startle devices, and anomaly may provide an explanation for this effectiveness.

Predators exhibiting a tendency to react inefficiently to anomalous stimuli would provide strong selection pressures favoring diversity in their prey. Diversity would result in an increased number of potential predator expectations, and a corresponding increased number of potential anomalous stimuli. Anomaly, within the limits of the advantage it provides, would then favor the origin and maintenance of considerable diversity in sympatric assemblages of closely related species. Hindwing diversity among moths in the genus *Catocala* may represent a response to pressures of this sort.

Whenever one suggests that selective advantages result from *inter-specific* hindwing diversity in *Catocala* moths, then the apparent problem posed by the lack of *intraspecific* hindwing diversity must be faced. If selection has favored diversity on the one hand, why has it opposed diversity on the other? This problem would be easily solved if the hindwings were involved in specific recognition; serving, for example, as releasers in mating behaviors and therefore as anti-hybridization devices. Thus far there is no evidence that the hindwings serve any such function, but the possibility must remain open until *Catocala* mating behaviors are thoroughly studied.

Another explanation for the lack of intraspecific hindwing variation may be related to the notion that parsimony would prevail with respect to the genetic bases of adaptive diversity in nature. Adaptive diversity in the case of *Catocala* hindwings is spread over an assemblage of species and seems to involve a large, but finite, number of categories, with each category being limited to a more-or-less fixed percentage of the total assemblage. The origin and maintenance of such diversity would seem to be more easily achieved if monomorphism, rather than polymorphism, characterized the species involved.

### SUMMARY

An attempt is made to describe and interpret beak-damage patterns found on the wings of *Catocala* moths. Two samples of beak-damaged specimens were studied: (1) 23 individuals recovered after being attacked by blue jays in aviaries; and (2) 65 individuals retained from a large sample of these moths taken at bait and lights in the field. Analyses of these moths resulted in a classification of beak-damage patterns into three major types: I (attacked while flying, tear from one wing); II (attacked while resting, tears from ipsilateral forewing and hindwing); and III (attacked while resting, beak-imprint on at least one wing). About half of the specimens in both the aviary and field samples were attacked while flying, the other half being attacked while resting.

The damage patterns obtained provide evidence that *Catocala* hindwings serve both deflective and startle functions. The probable nature of the startle function is discussed in detail, and it is suggested that a sudden, *unexpected* display of hindwings results in startle (and consequent unsuccessful completion of attack) in predators. The evidence for this view is provided by the crisp beak-imprints found on the wings of many *Catocala* specimens, and by the distribution of these beak-imprints among moths having different types of hindwings. *Anomaly* (defined as departure of prey from predator expectation, with resultant startle in the predator) is proposed as a functional and adaptive basis for hindwing diversity in *Catocala* moths.

### ACKNOWLEDGMENTS

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## AN ORCHID ATTRACTANT FOR MONARCH BUTTERFLIES (DANAIDAE)

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In view of the recent spurt of research on insect-flower relationships, and in particular the studies of Dodson and his co-workers on biologically active compounds in orchid fragrances (Dodson et al., 1969), it is especially interesting to discover an orchid which seems to have a practically "irresistible" attraction for monarch butterflies.

The monarch butterfly is unquestionably the best known butterfly species in the United States, and its biology has been the subject of a great deal of attention (Urquhart, 1960). In the Great Lakes states, as elsewhere, the monarch is famous for its swarming behavior preparatory to migration southward to the Gulf Coast and Mexico. Swarming is observed in the latter part of September and early October as a rule, although Moore (1960) reported a swarm in the middle of August, "... thousands of individuals on Seul Choix Point on the north shore of Lake Michigan," and Urquhart points out that migration actually has its beginnings in July.

During the first two weeks of autumn, monarch butterflies are frequent everywhere in the vicinity of Ann Arbor in southeastern Michigan. Their behavior is languid, and they soar slowly across fields and along roadsides, feeding especially upon flowers of various species of asters (e.g. *Aster azureus*, *A. ericoides*, *A. laevis*, *A. novae-angliae*). In cultivated legume fields the monarchs visit red clover (*Trifolium pratense*) and alfalfa (*Medicago sativa*) primarily. In general, butterfly diversity is low at this time during most years—a few sulphurs (*Colias philodice*, *C. eurytheme*), some worn swallowtails (*Papilio polyxenes* especially),

buckeyes (*Precis lavinia*), painted ladies (*Vanessa* spp.), and occasional skippers (esp. *Epargyreus clarus*, *Hesperia leonardus*, and rarely southern migrants such as *Atalopedes campestris*). Angle-wings (*Polygonia comma*, *P. interrogationis*) and mourning-cloaks (*Nymphalis antiopa*) are seen along woods edges and in old orchards. Although Milbert's tortoise shell (*Nymphalis milberti*) may become common in some years, monarchs and sulphurs dominate the picture. Wherever a lepidopterist drives on a warm, sunny day in early fall he finds *Danaus* and *Colias* on roadside asters, indicating a "good day" for butterflies.

On just such a day, 19 September 1970, we encountered an extraordinary circumstance. The greenhouses at the University of Michigan Gardens, located at Dixboro, Washtenaw Co., Michigan (approximately five airline miles from the center of Ann Arbor), were discovered to be "full of monarchs," as reported by one of our students. Looking into the matter we found that more accurately one part of one greenhouse was occupied by the butterflies. But the scene was remarkable; there were at least 200 individuals, as best we could count them. They were flying slowly to-and-fro, banging against the windows. At one corner of the house were five dozen butterflies settled on the glass panes. Something within this unit of the greenhouse was obviously attracting the monarchs. They would fly to the top of the greenhouse from the grounds nearby, and then fly down through the ventilators into the house. On 22 September 1970, the ANN ARBOR NEWS carried a story entitled "A Butterfly Invasion" describing the situation as follows. "More than 100 of the large butterflies are now gliding around the orchid greenhouse, beating their black-striped, orange-brown wings against the glass panes. . . . For some reason the butterflies have neglected adjoining greenhouses with their different plant varieties." The reporter had consulted entomologists for an explanation. One of them commented, "At this point it is anybody's guess why the monarchs have invaded this particular greenhouse. It could be something different about the temperature, or humidity of the air, or some special odor from the greenhouse." It was this last suggestion that we acted upon.

The so-called "orchid greenhouse" actually contained many other kinds of plants besides orchids, including bromeliads, ferns, and certain aroids. We made the assumption that some plant—either its vegetative parts or its flowers—was generating a substance that was so powerful as to attract the insect from the neighboring fields and woods to the roof of the greenhouse and then down through the ventilators. Of all the plants growing there, only one was visited selectively by the monarchs—an orchid. However, the butterflies would only casually stop

briefly, then leave, not to return. This particular orchid species has numerous flowers, but a monarch would come for its brief stop only to a single flower, and then depart. In spite of this seemingly almost random interest in the flower, we moved the orchid plant into another greenhouse in order to observe what effect this might have. We soon learned that there was no question about it: this was the plant. Very soon the monarchs now floated down into this greenhouse, as before they had in the other. And no new monarchs flew into the house where they had previously been attracted.

The orchid has been identified as *Epidendrum paniculatum* Ruiz & Pavon, which is a widespread species (or species-complex) ranging from Central America to Peru. The plant is commonly and readily grown in horticulture for its somewhat fragrant flowers, these about 2 cm. across, brownish to rose-white in color, which are borne in spreading, many-flowered panicles a foot or more in length. Historically this is one of the best-known members of its genus. Over three-quarters of a century ago, it was written (Veitch & Sons, 1887-1894) that this plant is, "One of the first epiphytal orchids known to science, and one of the most widely distributed of the genus. It was discovered more than a century ago by the Spanish botanists Ruiz and Pavon, near Huayaquil (Guayaquil?) in Peru, and has since been gathered by various collectors in many localities in tropical South America widely remote from each other, but always at a considerable elevation on the Cordilleras from Bolivia northwards to Venezuela. As a species it is very variable, due doubtless to diversity of station and its wide distribution . . . ." Dodson has written me of his personal observations in Costa Rica and Ecuador that this species or closely related ones will attract ithomiid butterflies. He suggests that perhaps the substances involved in the attraction of monarchs are pyrolizidine alkaloids. The orchid is, as indicated, widespread in cultivation and therefore readily obtainable for experimental work.

Morrell (1960) reports that heliotrope (*Heliotropium indicum*, Boraginaceae) is attractive to danaiids. Plants dried from 48 hours to a fortnight may be used. It should be interesting to determine whether there is a common factor in the substances produced by the orchid described here and the heliotrope.

We were especially curious to learn whether the *Epidendrum* orchid attracted the sexes differentially, so we kept records for two years on the numbers that came into the greenhouses. We also set up what might be called "an obstacle course" to see whether we could entice the monarchs into the court of a large building, forcing them to fly up and over the sides, using the orchid as an attractant.

Both in 1970 and 1971 we missed the main flights. In 1970, on 21 and 22 September there were still numerous butterflies being attracted into the greenhouse (a total of 119 for both days), but the weather became cloudy and the temperatures dropped, so they were considerably less common, the numbers dropping to 0-16 per day. Observations in the field after 22 September indicated that monarchs were either extremely rare or absent; nevertheless, a few kept showing up at the greenhouses. Males were in slight excess—66 males to 51 females from 22 to 30 September inclusive. In 1971, the orchid plant came into bloom rather late, but we kept records for the period 29 September through 5 October inclusive, and counted a total of 47 males and 50 females. The sex ratio of attracted monarchs thus appears to be approximately 1:1.

In 1972 we experimented to find out how much "trouble" the butterflies might undergo to reach the flowers of this orchid by bringing it into the Natural Sciences Building on the Main Campus of the University of Michigan, Ann Arbor. Here in the center of the city, in a building four stories high, the plant was placed in a third floor office near a window opening into the central courtyard. In order for a butterfly to reach the plant it would have to fly *over* the walls of the building and then select the right window out of over 100 facing the court. So that the butterfly would not see the flowers, the venetian blind was lowered but the window left open. In spite of these seeming obstacles, three males did appear at and entered through the window, indicating that the attractive forces of this orchid for monarchs must be very strong indeed. The period of our "obstacle course" test was 15-17 September, and the butterflies came from 0955-1235. One butterfly appeared each day.

From the evidence that we have seen, *Epidendrum paniculatum* is a powerful attractant for monarch butterflies. We have made no attempt to identify the compound or compounds which are active in the attraction, but various persons have described their subjective interpretation of the scent of the flowers as "lemony" or "slightly spicy." It is to be hoped that further studies of this attractant can be made, and also that students of monarch butterfly biology may be able to use the orchid in their research, e.g., for luring migrating specimens into buildings or other enclosures for purposes of marking.

I wish to acknowledge the help of Caloway Dodson, Edward L. McWilliams, and L. J. Melton in making this study. I especially thank Louis Ludwig for his interest and help in gathering data.

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ON *ORNITHOPTERA PRIAMUS CAELESTIS* ROTHSCILD,  
*DEMOPHANES FRUHSTORFER* AND *BOISDUVALI*  
MONTROUZIER (*PAPILIONIDAE*)

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In October and November of 1970 and 1971, the senior author undertook two trips by boat to Trobriand Islands, Louisiades Archipelago and Woodlark Island, to study the life histories of and collect *Ornithoptera priamus caelestis* Rothschild, *O. p. demophanes* Fruhstorfer and *O. p. boisduvali* Montrouzier. This article consists of field notes, descriptions of immature stages and a selection of photographs taken in the field by H. Borch. The young stages are described here for the first time. The taxonomic and phyletic considerations on the imagines are by F. Schmid. The eggs and the first three larval instars are identical in the three forms and likely are very similar to those of other subspecies of *priamus*; therefore, they are not described here.

*Ornithoptera priamus caelestis* Rothschild

General Observations

Imagines and immatures were seen and collected on Misima Island (Misima, Liag and Larama), Nimoa Island (Nimoa), Sudest Island, Hemenaei Island and Moturina Island. The food-plant is *Aristolochia tagala*. The *ova* are always laid singly on the food-plant or on any nearby object or plant. An ant, *Oecophylla smaragdina* (native name, *Kura Kum*), has been observed preying on the eggs, sometimes sucking dry dozens of them. The newly emerged larvae eat their egg-shells and sometimes turn also to other unhatched eggs and completely devour them.



The *larvae* are always found on the food-plant, but when they are moulting they crawl for shelter into nearby shrubs. We noted a number of cases of cannibalism. This usually occurs just after ecdysis when larvae will attack and devour newly formed pupae. We once observed three larvae completely devour a pupa.

The *pupae* are usually found on the underside of the leaves, or on nearby shrubs, or on grass or even sometimes on trees as high as 20 ft. from the ground. They are usually found in shady situations.

The *imagines* were seen mostly in the hills, as high as 300 ft. elevation, and very rarely at sea-level. Often, early in the morning, males were observed flying directly to female pupae to check if they were emerging. They hovered over the pupae for some minutes and finally flew away. They were observed doing this day after day. When a female finally emerged, it mated before its wings were fully dried.

### Taxonomy

*Fourth and fifth-instar larvae* (Fig. 1). Basic colour intense velvety black. All tubercles partially red, none cream towards the base, except the dorsal tubercles on 4th abdominal segment. Cream saddle-marks small, not extending far laterally. Length at maturity: 67–75 mm.

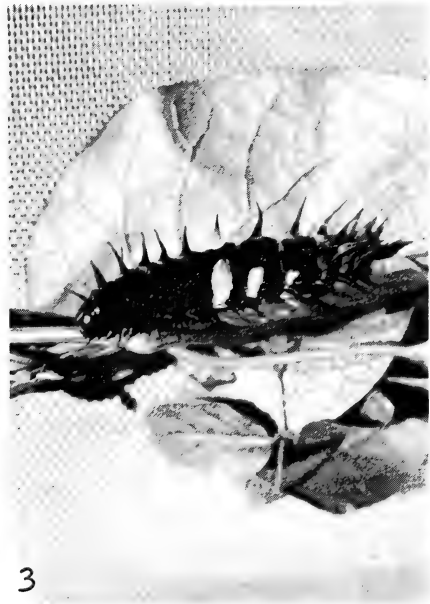
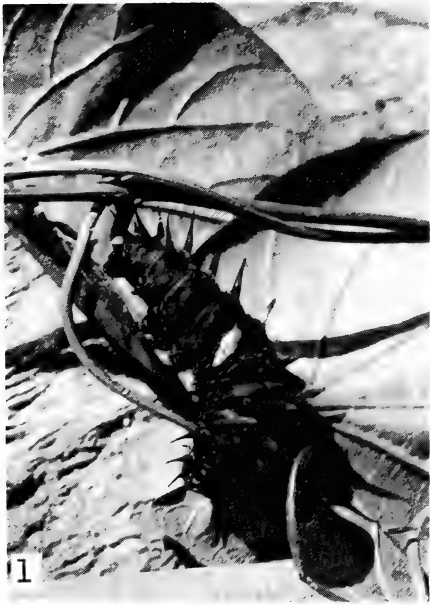
*Pupa* (Fig. 2). Basic colour rather dark brown. All markings very pale and contrasting. Two bright yellow areas: a small one on the pronotum and a large one on the metanotum and all abdominal segments, limited laterally by the wing-cases and abdominal tubercles. Length 48–50 mm. Pupal period: 22–26 days.

*Imagines*. This small blue form is well known taxonomically. We shall not describe it again, but simply indicate variations that we observed on 36 ♂♂ and 30 ♀♀ at our disposal. The anal blue band of the anterior wing is always narrower than the radial band and usually regular; in half of our specimens, it is interrupted in the middle of the anal margin. The number of the black discal spots on the posterior wing varies from 5 to 0, the usual number being 3 or 4. Almost all specimens show a black shadow on the discal cell and some have the whole disc powdered with black up to the discal spots. The extension of the black area is proportional to the size of the discal spots. We have seen only two specimens with uniformly blue posterior wings. Three specimens out of four have a yellow translucent spot in the cell Sc + Rl - Rs. Specimens with yellow marginal dots have been reported and named *flavopunctata* Rousseau-Decelle, but only one of our males shows a pair of these dots.

The female is very constant. The basic colour of both wings is deep brown. Both wings are very spotted, with a large oval mark in the discal cell of the anterior wings. The spots are uniformly rather dark.

### Phyletic Position

Along with *urvilleana*, *caelestis* is the only known blue subspecies of *priamus*. An interesting point would be to know if it is derived from *urvilleana* (or from a common blue ancestor) or if it evolved from a green form like *poseidon* and acquired the blue colour in a parallel



Figs. 1-2. *O. p. caelestis*: 1, fifth-instar larva; 2, pupa. Figs. 3-4. *O. p. demophanes*: 3, fifth-instar larva; 4, fourth-instar larva (other specimen).

manner to *urvilleana*, as did other subspecies like *hecuba* and *bornemannii* which show a tendency to be partly tinted with blue.

The absence of the coloured cubital band on the anterior wing separates *caelestis* from the complex of *poseidon*, *demophanes*, *boisduvali*, *bornemannii*, *hecuba*, *arruana* and *pronomus* and readily places it in the line of *urvilleana*, *priamus*, *admiralitatis*, *richmundia* and *euphorion*. The regularity of the anal band on the anterior wing and its frequent interruption along the anal margin separates it also from the four last named subspecies and relates it to *urvilleana*. The posterior wing is less rounded than in *priamus*, *admiralitatis*, *richmundia* and *euphorion* and has its anterior apical angle slightly protruding, as in *urvilleana*. Furthermore, the disc of the same wing is always more-or-less clouded with black, again as in *urvilleana*. Below, the posterior wing is blue with a yellowish-green marginal border in both forms. This shows rather convincingly that *caelestis* is the nearest relative of *urvilleana* and that their blue sheen is a monophyletic character inherited from an already blue common ancestor.

### *O. priamus demophanes* Fruhstorfer

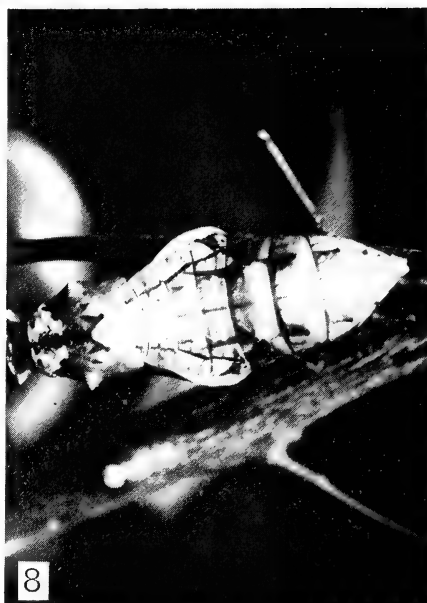
Since the original description by Fruhstorfer in 1913, from the Trobriand Islands, no mention of this form has been recorded in the literature. Its status is universally considered as doubtful. However, specimens are not rare in collections. The question we shall try to resolve here is if this form is a good subspecies or indeed a simple variation of *poseidon*, as are so many of Fruhstorfer's so-called aberrations.

### Taxonomy

*Fourth and fifth instar larvae* (Figs. 3-4). Basic colour velvety black, in some cases grey-black. Tubercles on thoracic segment 1 and all lateral tubercles black. Dorsal and laterodorsal tubercles on thoracic segments 2 and 3 and all abdominal segments partially red, without cream colour. Cream saddle-marks on abdominal segment 4 broad, extending laterally to the spiracles and almost contiguous on the dorsum. Two additional cream saddle-marks usually on segments 5 and 6, decreasing in size (Fig. 3). A few specimens with these three marks on segments 3, 4, 5 (Fig. 4) or only on segments 4 and 5. One large larva measured 90 mm in length. Duration of larval period 25-29 days.

*Pupa* (Figs. 5-6). Basic colour dull yellowish-brown, in some cases tinted with pinkish. Dorsal saddle-mark bright yellow. A fine brown line middorsally through the saddle-mark to last abdominal segment. A heavy dark brown line laterally below the wing cases. Tenulae yellow. Two short and sharp black-tipped processes on abdominal segments 5 to 8. Average length 60 mm. Pupae period: 21-28 days.

*Imagines* (Figs. 10-12). From a dozen pairs that we have studied, we illustrate three specimens showing the extremes of variation.



Figs. 5-6. *O. p. demophanes*: pupae. Figs. 7-8. *O. p. boisduvali*: 7, larva; 8, pupa.

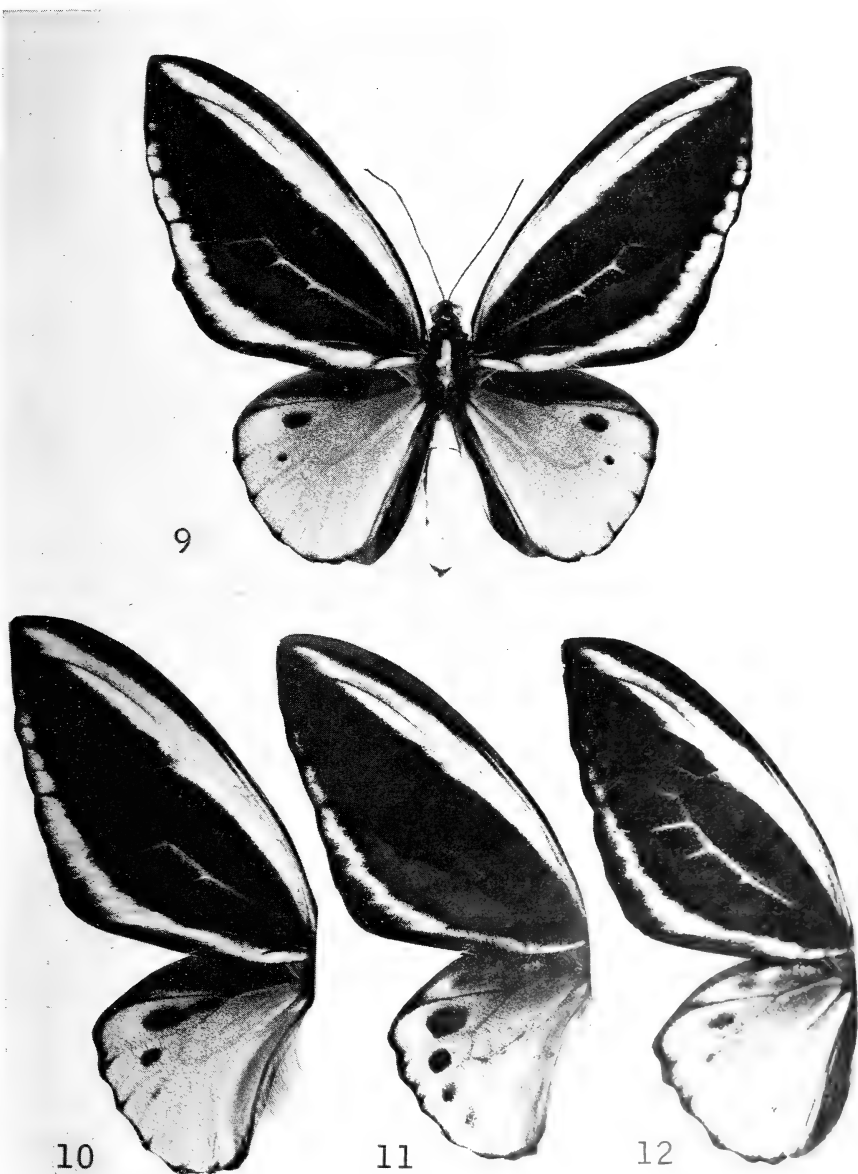


Fig. 9. *O. p. poseidon*, ♂. Figs. 10–12. *O. p. demophanes*, ♂♂, variation of three specimens.

### Phyletic Position

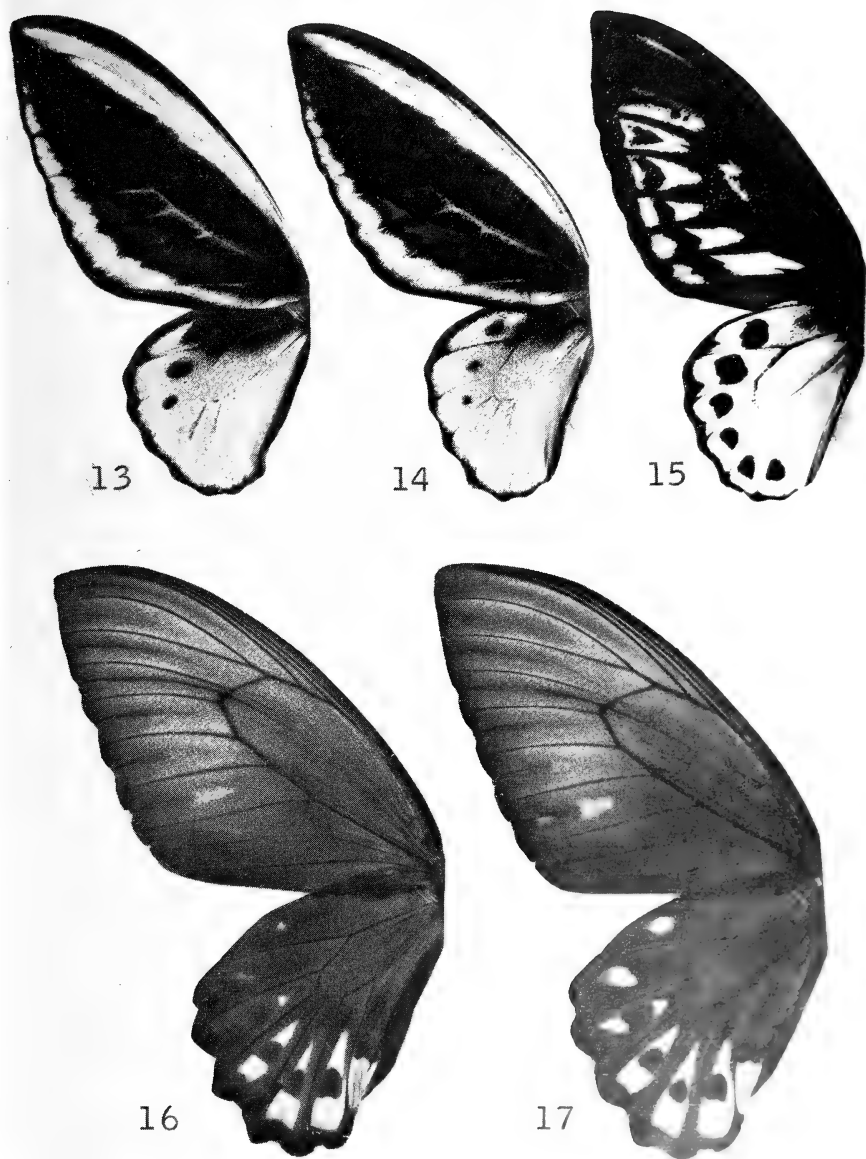
To assess the status of *demophanes*, we shall compare it with *poseidon* to see if the differences are important and constant enough to be considered of subspecific importance. *Poseidon* is a very variable subspecies in size as well as in pattern. One of the patterns rather frequently observed is characterized by the cell Sc + Rl - Rs on the posterior wings being entirely black and with 2 or 3 small black discal spots sharply decreasing in size. A specimen of this form is shown on Fig. 9, but it is clear that many intermediates exist. This type of coloration is not peculiar to *poseidon*, since we know it for *admiralitatis* and *bornemanni* also. It is to this form of *poseidon* only that we shall refer below.

The ♂ of *demophanes* is remarkably constant in size as well as in pattern. Likely, it is genetically much more homogenous than *poseidon*, which can be expected in a form geographically restricted to an island. The green colour of *demophanes* is more often tinted with blue than is *poseidon*, though not frequently. In *poseidon*, the radial and anal bands are broad, regular and of equal width. In *demophanes*, the radial band is slightly narrower than in *poseidon*, the anal band is constantly and definitely narrower than the radial one, being sometimes reduced to a simple line (Fig. 11) and somewhat irregular. The reduction occurs from the posterior and outer sides with the result that the black margin is broader than in *poseidon*.

The cell Sc + Rl - Rs of the posterior wing is sometimes entirely black, sometimes green, but always with a certain amount of black. The number of the black discal spots on the wings varies from 1 to 5, the first one often merging with the black area. The second one is the largest and the size of the following ones decreases more rapidly than in *poseidon*. Under the posterior wing, the discal spots are always clearly bigger than in *poseidon* and with frequent black indentations from the black margin in the cells Rs - M1 and M1 - M2. The yellow translucent spot on the cell Sc + Rl - Rs is of course always absent in *demophanes* as well as in the form of *poseidon* considered here, but on one specimen of the latter we have noted two pairs of yellow marginal dots in the cells Rs - Rl and M1 - M2; these dots always seem to be absent in *demophanes*.

The ♀ of *demophanes* is also very stable in size and coloration. We doubt that it can be separated from the highly variable ♀ of *poseidon* but it can be described as follows: basic colour of the anterior wing light brown, except on the three margins that are dark brown. Spots numerous, dark gray, always present in the discal and the marginal cells.

Basic colour of the posterior wing dark brown, with the spots as in *poseidon*.



Figs. 13-17. *O. p. boisduvali*: 13-15, ♂♂, variation of three specimens; 16-17, ♀♀, variation of two specimens.

The typical imaginal characters of *demophanes* are neither numerous nor important. But their constancy plus the remarkable fact that the caterpillar has three saddle-marks where *poseidon* shows only one, plus its insular isolation lead us to think that it is genetically distinct enough from *poseidon* to deserve a full subspecific status. It certainly evolved from specimens of the form of *poseidon* we considered above which populated the Trobriand Islands not long ago and became isolated there.

### *O. priamus boisduvali* Montrouzier

Since its original description by Montrouzier, from Woodlark Island in 1852, only very few references have been made of this subspecies in the literature. They are all brief expressions of doubt on its validity, since Montrouzier's description is insufficient to distinguish it. No specimens seem to be present in collections. We are very glad to have rediscovered this interesting subspecies that was forgotten or ignored for 120 years and to make it known adequately to the lepidopterological world.

### Taxonomy

*Fourth and fifth-instar larvae* (Fig. 7). Basic colour velvety black. All tubercles partially red, those on abdominal segments 5 to 10 red and cream near the bases. Cream saddle-marks on abdominal segment 4 extending from the bases of dorsal tubercles and narrowing to the spiracles. Length 90 mm. Duration of larval period 25–29 days. Feeding on local race of *Aristolochia tagala* with typical flowers and seed-pods but with a slight pink colouring on the stems.

*Pupa* (Fig. 8). Basic colour dull yellowish-brown as in *demophanes*, but dorsal half sometimes darker than ventral half. Seen dorsally the outer edge of wing cases seeming to protrude more laterally.

*Imagines* (Figs. 13–17). This subspecies shows a remarkable stability in all of its characters because of the small number of the populations and its isolation on a small island. Since it is closely related to *poseidon* we shall quote here only the characters that distinguish the two subspecies and shall again refer only to the form of *poseidon* we discussed above and illustrated in Fig. 3. Of the 20 pairs we studied, we selected four specimens showing the extremes of variation. Both sexes are small. Expanse of ♂: 8–12 mm; ♀: 13–15 mm.

### Phyletic Position

The green colour of the ♂ is distinctly more acid and bluish than in *poseidon* and remarkably constant. The outer margin of the anterior wing is slightly more tilted and the anal angle rounded. The posterior wing is comparatively small, very rounded, even more so than in *euphorion* and the outer margin shows only a very slight crenulation. On the anterior wing, both the radial and anal bands are slightly narrower than in *poseidon*, of equal width and the latter is slightly irregular. The cubital band is always present but never very well developed. On the same wing below, there is always a small coloured spot in the discal cell, the other spots being slightly reduced.



On the posterior wing there is a black area, usually large, extending not only into the cell Sc + Rl - Rs as in *poseidon*, but also into the discal cell and into the anterior angle of the cell M1 - M2, which is never the case in *poseidon*. The apex of the first mentioned cell is always green. The number of the black discal spots varies from 1 to 5, the first one merging often with the black area. The black marginal border is well developed. The underside of the posterior wings is powdered with black at the extreme base. The discal spots are slightly larger than in *poseidon* and there are occasionally short black indentations from the black margin. Yellow spot and dots are always lacking.

The ♀ is the darkest of all the subspecies of *priamus* known to us. The basic colour of the anterior wing is brown-black but generally washed with grey in all the marginal cells from the apex of the discal one. The only constantly present spot is in the cell Cu1 - Cu2 and is divided into two; it is present below only, though it is visible by transparency from above. There might also be two tiny spots in the cells M3 - Cu1 and Cu2 - 2A, but they are not visible from above.

The posterior wing is as shown in Figs. 16-17. Above, the spots are usually very dark, but are lightened to cream yellow in the cell Sc + Rl - Sr. Beneath, the spots are distinctly lighter. They can be pure yellow, especially the two anterior ones, but the three posterior ones remain clouded with grey.

Montrouzier's type very likely disappeared long ago, but we do not find it necessary to designate a neotype, since there is no doubt about the identity of the subspecies. *Boisduvali* is obviously derived from the same form of *poseidon* as *demophanes*. It has evolved in the same direction but has gone further, probably because its original population was isolated at an earlier period or because Woodlark Islands are more remotely distant from the New-Guinean mainland than are Trobriand Islands.

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PROJECT PONCEANUS: A REPORT ON FIRST EFFORTS TO  
SURVEY AND PRESERVE THE SCHAUS SWALLOWTAIL  
(PAPILIONIDAE) IN SOUTHERN FLORIDA<sup>1</sup>

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In this time of environmental awareness the subject of butterfly conservation is receiving increasing attention in the United States. Lepidopterists have long been concerned with decreasing numbers of certain species; but only recently have efforts been undertaken to protect habitats and rare butterflies that populate them. Although the English have accomplished much in this field (such as the reintroduction of the Large Copper, *Lycaena dispar* Haworth), Americans have made only small endeavors in the past. Rawson (1961) attempted unsuccessfully to introduce a small population of *Eumaeus atala florida* (Röber) into the Everglades National Park; but with more groundwork and support, future efforts along these lines may prove successful.

The Schaus Swallowtail, *Papilio aristodemus ponceanus*, was described by Schaus (1911) from specimens he collected in the Miami area in May, 1898. Originally considered a separate species, and considered so by Holland (1930, 1931), it was given subspecific rank by Barnes and McDunnough (1917). Bates (1934) and subsequent workers have continued referring to it as a subspecies of *aristodemus* Esper.

The popular and rather sensationalized report by Grimshawe (1940) of her discovery and rearing of *ponceanus*, with statement of its extinction on Lower Matecumbe Key (a paper considered by some to be the "last word" on the butterfly) did much to add to the impression among lepidopterists that *ponceanus* is a rare insect in Florida. The three articles by Henderson (1945a, b; 1946) summarized known information, and proved that the butterfly had not been rendered extinct by the September 1935 hurricane, as Grimshawe had claimed. Although some specimens were no doubt missed, Henderson's papers listed collecting localities, dates, and owners of known specimens taken through 1945. Additional records since then are apparently not recorded in the literature. Klots (1951) and Kimball (1965) discussed *ponceanus* as rare, and urged

<sup>1</sup> University of Louisville Contributions in Biology No. 157 (New Series).

collectors to help preserve it. Young (1955) mentioned it as a butterfly one would be happy just to see, much less capture, and also recorded that the specimen figured in Holland (1931) was from Key West. C. V. Covell, Jr. took a ragged female on Key Largo on 31 March 1961 (reported in the Field Season Summary of the Lepidopterists' Society for that year)—an unusual date, since all other records apparently fall between mid-April and late June. Collections of *ponceanus* during the 1960's seem few, and may indeed reflect some degree of scarcity. We believe, however, that it was merely not sought much by collectors.

Rutkowski (1971) gave good new ecological and biological information, based on his 1970 experience with *ponceanus* on Key Largo. This article, plus a letter circulated by Kent H. Wilson urging that lepidopterists take a hand in preserving what he thought was the last population in the U.S. of *ponceanus*, stimulated the authors to undertake such a project.

### The 1972 Survey Trip

We first decided to find out if *ponceanus* is really as threatened as people seemed to think. We planned to visit southern Florida in early May 1972, and look for the swallowtail in lands protected by the U.S. Government from both collectors and developers. Through personal communication with Dr. William B. Robertson, Research Biologist at Everglades National Park, we learned that Torchwood (*Amyris elemifera* L.), the primary foodplant of *ponceanus*, is not known to be common anywhere in the Everglades National Park, but is well established on some of the keys making up the Biscayne National Monument. A secondary foodplant, Wild Lime (*Xanthoxylum fagara* L.), while present in the Everglades National Park, was not thought to be very common. Robertson agreed to arrange a trip for us to Biscayne National Monument on 11 May.

Through a travel grant from the Tom Wallace Conservation Fund at the University of Louisville, Covell and student assistant Gregory Florence drove to Florida City, where a rendezvous with Rawson was accomplished on 10 May. After a preliminary planning session with Robertson and Dr. William Hendrickson, Ecologist, at Everglades National Park headquarters, the rest of the day was spent making camp at Long Pine Key campground, and seeking *ponceanus* in the Flamingo area of the Park (where *X. fagara* was reported to be growing). *Papilio cresphontes* Cramer was common, but no *ponceanus* were seen.

Early on 11 May we met Dale Engquist, Superintendent of Biscayne National Monument, and Ranger George Sites, at the Monument headquarters at Homestead Bayfront Park. Ranger Sites was to be our guide

and boatman on the expedition, and botanist George Avery from Miami's Fairchild Garden came along to seek two rare plant species. A few light showers preceded hot, humid weather as we motored toward the first of the keys we were to visit.

We tied the boat to the tangle of Red Mangrove (*Rhizophora mangle* L.) that completely surrounded the first island, and picked our way some distance through this dense vegetation. When we reached the higher hardwood hammock, George Avery pointed out some Torchwood trees. A swallowtail appearing to be *ponceanus* flew past at some distance; and another was netted by Covell as it flew beside him. The presence of the species there was verified; we saw about 15 more in as many minutes before we worked our way back to the boat. The second island was more easily penetrated, and *ponceanus* were seen (two taken) flying along or across paths which honeycombed the hammock. None were seen on a smaller, third key. Upon our return to the mainland, we were assured that Monument officials would be on the lookout for unauthorized collectors on these islands.

On 12 May we looked in other parts of the Everglades National Park for *ponceanus*, but found none. The following day took us to Key Largo, where we surveyed the *ponceanus* population along paths from Rt. 905 toward the Atlantic with Terry Dickel of Homestead. We took several specimens, all males, varying from fresh to slightly worn in condition. None were observed visiting blossoms, and they were not really abundant. Dickel informed us that the weekend before he had seen six collectors on Key Largo, apparently seeking *ponceanus*. We found very few eggs and larvae on the foodplants, and later learned that one collecting group had taken a large number of ova from foodplants there through systematic examination of the leaves. The Key is still not developed to any great extent; but we did find that the spot where Rutkowski had made his observations in 1970 is apparently gone now, bulldozed to form a marina-community called "Worlds Beyond." We determined this from careful directions kindly given us by Rutkowski through personal communication.

Other butterfly species recorded on 11 May in Biscayne National Monument included: *Epargyreus zestos* Geyer, *Battus polydamas* (Linnaeus), *Papilio cresphontes* Cramer, *Ascia monuste* (Linnaeus), *Phoebis agarithe maxima* (Neumoegen), *Hemiargus ammon bethunebakeri* Comstock and Huntington, *Eunica tatila tatilista* Kaye, *Phyciodes frisia* (Poey), *Heliconius charitonius tuckeri* Comstock and Brown, *Dryas julia cillene* (Cramer), and *Danaus gilippus berenice* (Cramer). On 13 May on Key Largo we recorded the same (except *B. polydamas*, *A. monuste*, *P. frisia* and *D. gilippus berenice*) plus the following: *Wallengrenia otho*

*otho* (Smith), *Polygonus leo* (Gmelin), *Appias drusilla* (Cramer), *Marpesia petreus* (Cramer), and *Agraulis vanillae* (Linnaeus).

#### DISCUSSION

We felt that we had accomplished our mission, in that *P. aristodemus ponceanus* seems to be well established on at least two of the islands in the Biscayne National Monument. Except for the uncontrollable phenomenon of climatic traumas (freezes and hurricanes), the Schaus Swallowtail seems safe from real or imagined threats of extinction via development, pesticides and overcollection. On Key Largo, developers do pose some threat, but probably not for some years to come. There are over nine miles of relatively undisturbed hardwood hammock along Rt. 905 from Rt. U.S. 1 to Ocean Reef at the northern tip. We feel that *ponceanus* is probably established in some other pockets in the keys, and hope to continue our survey activities. No efforts to introduce *ponceanus* to other sites seem to be necessary to the survival of the U.S. *ponceanus* population.

This butterfly does, however, have a tenuous foothold in the United States, and we urge collectors to give this species a conservationist's concern when collection or purchase of specimens are considered.

#### ACKNOWLEDGMENTS

As "Project Ponceanus" progressed, many people contributed to its implementation in various ways. We are grateful to all for their help, and especially to the following: Dr. William B. Robertson, Research Biologist, Everglades National Park, for making our visit possible; Superintendent Dale Engquist and Ranger George Sites of Biscayne National Monument; Mr. Terhune S. Dickel, Homestead, Fla.; Mr. Gregory G. Florence, Bardstown, Ky.; Dr. W. Hendrickson, Ecologist, Everglades National Park; and Mr. Frank Rutkowski, New York City. We are also indebted to Drs. William Clay and Burt Monroe, Jr. of the Biology Dept., University of Louisville, for making available to us funds from the Tom Wallace Conservation Fund.

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## NOTES ON THE LIFE CYCLE AND NATURAL HISTORY OF BUTTERFLIES OF EL SALVADOR. I. *PREPONA* *OMPHALE OCTAVIA* (NYMPHALIDAE)

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For a number of years my sons and I have been collecting and breeding butterflies in the vicinity of San Salvador (600–900 m. altitude), capital city of El Salvador. Since the life cycle of many neotropical butterflies is not completely known, many species have been classified solely on the morphological characteristics of the adults. It seems desirable therefore to place on record the various facts that we have found. This we intend to do in a series of articles dealing with the life cycle, host plants, and general natural history of the species we have been able to breed.

A major difficulty has been the identification of the species described, as we are dependent on A. Seitz (ed.) (1924, Macrolepidoptera of the World, Vol. 5. The American Rhopalocera 1907–14), that is, according to many modern authors, "... replete with errors which cause much confusion." (Klots, 1960). To partially overcome this handicap, Drs. F. H. Rindge and A. B. Klots of the American Museum of Natural History, and L. D. Miller of the Allyn Museum of Entomology, have made at least

tentative determinations of the material. Specimens of adults and of their early stages have been placed in these museums, so as to be available for students of the groups.

To give a clear idea of the habitats of the species described, it seems appropriate to make a rough description of the country. El Salvador is the smallest country of Central America, and the most densely populated of continental America: 21393 km, with 3,500,000 hab. It has the shape of a rough parallelogram that lies between  $87^{\circ} 40'$  and  $90^{\circ} 13'$  east, and  $13^{\circ} 11'$  and  $14^{\circ} 40'$  north, having Guatemala to the west, Honduras to the north, and the Golfo de Fonseca to the east. It has shores only on the Pacific Ocean (south). Being separated from the Caribbean by the high mountains of Sierra Madre, its climate is not affected by the monsoon conditions. There are six months of dry season (November to April) and six of rainy season (May to October). This fact influences greatly the flora and thence, the fauna. According to Serrano & Serrano (1972), only 348 species of Rhopalocera have been reported from El Salvador.

There are four main climatic zones: hot tropical lowlands (0–800 m. altitude), warm tropical plains (800–1200 m.), cool tropical highlands (1200–1800 m.) and cold tropical highlands (1800–2700 m.). In the lowlands, cotton, rice, sugar cane, corn and cattle are grown. In the warm plains, there are sugar cane, corn, cattle, some coffee, fruits and vegetables. In the steeper cool highlands, there is mostly coffee, with some vegetables, fruits and flowers. The cold highlands are located in the NW part of the country, and there some forests are left.

Due to the country's dense population, most of the land is under intense cultivation, so what is left of wild vegetation consists of heavily disturbed second-growth plant communities, localized mostly along rivers and ravines. An advantage for the collector of insects in general and butterflies in particular is that when being based in the capital city, San Salvador, he can find a wide range of altitudes and habitats within a range of 50 km, making it possible to find about 90% of the local species without the need of long traveling.

It is within this range that we have collected eggs and or larvae of about 130 species of butterflies in order to study their early stages and developmental time. Among these species is *Prepona omphale octavia* Fruhstorfer, a rather scarce and elusive species of the family Nymphalidae. Some authors, e.g. Brues, Melander & Carpenter (1954), place the genus *Prepona* in the subfamily Nymphalinae, but prefer to use the more widely accepted subfamily Charaxinae. In this article we relate what we have found about the life cycle, behavior of immature stages and adults, host plant and habitat of *Prepona o. octavia* in El Salvador.

Since 1968 we have observed adults of *P. o. octavia* at different altitudes, ranging from sea level to about 2000 m., mostly in the neighborhood of coffee plantations (which can be considered man-made forests, due to the local technique of planting the coffee under shade trees, mostly *Inga* spp.), or near rivers and ravines. Yet, until December 1971, we had been unable to obtain eggs. At that time we found a female in the process of oviposition right in town, and three eggs were collected. Once the food plant was identified, a two-month search was made in an area of 20 blocks, and 21 larvae in different stadia were found. Fifteen were collected and six left on the plants.

The eggs were photographed and put in individual plastic bags, as were the 15 larvae. The larvae were supplied with fresh leaves of the host plant every two days. Attempts were made to determine the developmental time under laboratory conditions, to photograph and measure the different stadia, and to keep material of the early stages preserved in alcohol. The transparent bags were kept under ambient temperature and lighting conditions until the emergence of the adults. No moisture control was made.

### Life Cycle Stages

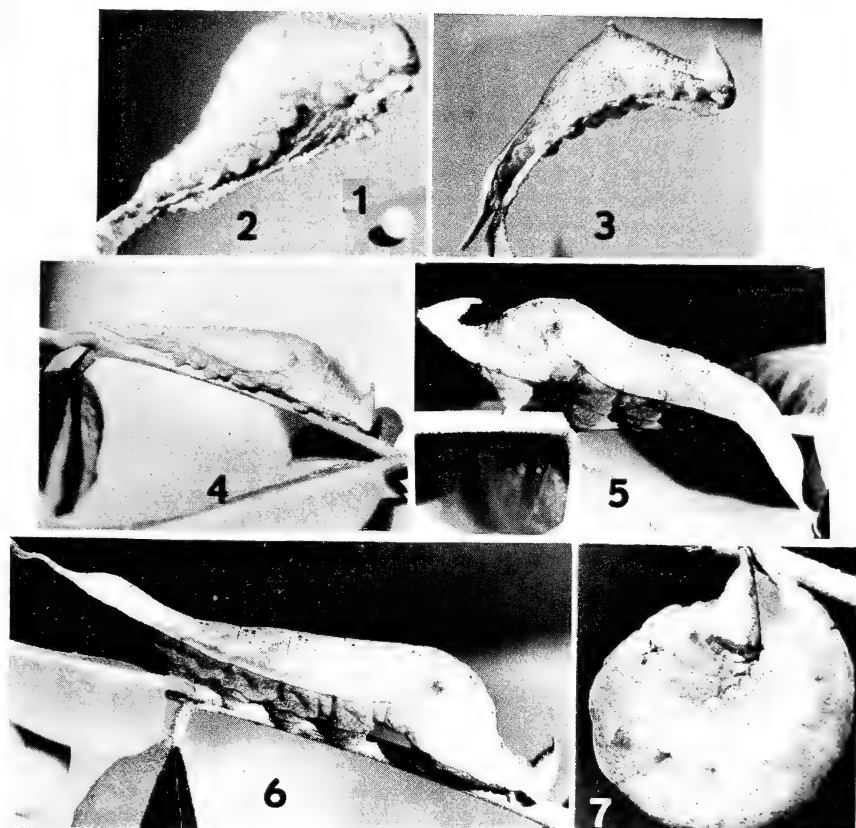
**Egg.** Pure white, spherical with slightly flattened base and depression at micropyle, which is surrounded by a tiny ridge. No visible sculptures at 10× magnification. Diameter, 2.5 mm. All hatched in 7 days.

**First instar larva.** Light brown all over. Head naked and roundish, slightly thicker than thoracic segments. Body naked, thickening gradually to 2nd abdominal segment, which is made prominent by two warts located one at each side, at subdorsal area, lighter brown than the general color. Body tapering to 6th abdominal segment then keeping about the same thickness to the 10th, which ends in two short and stubby "tails." Anal prolegs slightly smaller than the other prolegs. Lateral ridge starting at thoracic segments subspiracularly, ending low at side of first abdominal segment. Another lateral ridge originates at 2nd abdominal segment between the wart and spiraculum, which is placed much higher than the rest, and terminates at the "tails" of the 10th. Spiracula of subsequent abdominal segments are placed under this ridge, except on the 8th abdominal segment where it is above, and so out of line with the others. Larvae at emergence 3.5 to 4 mm, growing to 1.3 cm before moulting. Time, 12–13 days.

**Second instar larva.** Darker brown on upper surface of body, where the two warts on 2nd abdominal segment are conspicuous due to lighter shade. Head, under-surface of body, and caudal zone all around, light brown. Head pyramid-shaped, with two fused epicranial horns, projecting higher than humped abdominal segments (1st and 2nd). Distinct "neck" formed by narrow 1st and 2nd thoracic segments. True legs tiny on 1st, slightly bigger on 2nd, and still bigger on 3rd thoracic segments. Anal prolegs much reduced as compared to the other prolegs. Tails on tenth abdominal segment elongated. Head and body always naked, but tiny grainings most apparent around upper thoracic segments. Ridges lighter colored than rest of body. Reaching about 2.5 cm in 8–10 days.

**Third instar larva.** Lighter brown than 2nd instar. Thin black lines dorsally at thoracic segments. Grains on head more noticeable and fused horns with tip slightly





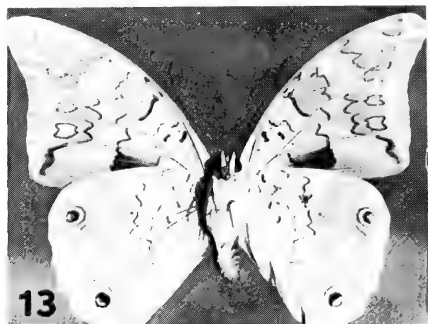
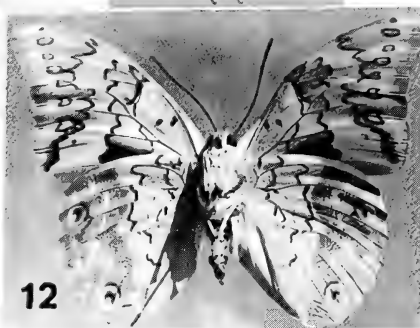
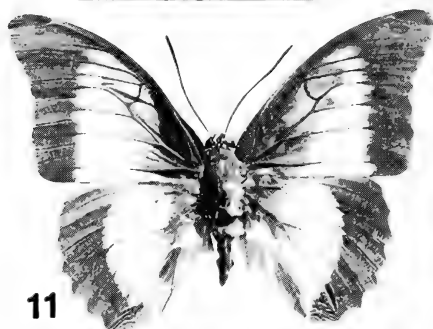
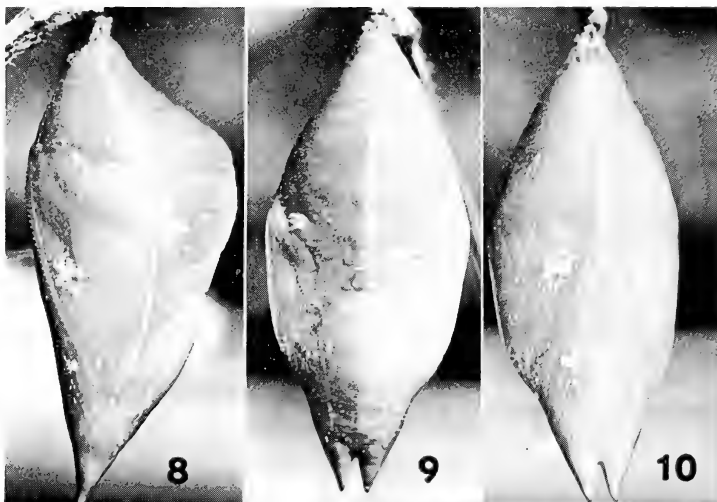
Figs. 1-7. *Propona omphale octavia* Fruhstorfer: 1, egg (2.5 mm); 2, first instar larva 10 days after hatching (1 cm); 3, second instar larva 2 days after moulting (1.7 cm); 4, third instar larva 10 days after moulting (3.8 cm); 5, fourth instar larva 10 days after moulting (5.2 cm); 6, fifth instar larva 12 days after moulting (7.2 cm); 7, prepupa.

curved back. Anal prolegs still more reduced, and tails more elongated and slightly crooked. Reaching about 3.8 cm in 9-12 days.

**Fourth instar larva.** Base of true legs on 3rd thoracic segment and prolegs on 3rd, 4th, 5th and 6th abdominal segments much thickened, seeming to start just below spiracula. Body develops an indefinite and faint pattern of darker brown shade dorsally. Anal prolegs still more reduced. Tails longer and quite crooked. Reaching about 5.2 cm in 11-14 days.

**Fifth instar larva.** Same aspect as 4th instar, but much longer and thicker, so that head appears disproportionately small. Very much reduced anal prolegs. The day before entering pre-pupal stage, color becomes "translucent" light brown. Reaching 7 or 7.5 cm in 19-26 days.

**Pre-pupa.** Thick and incurvated, so touching with the horns the twig from which it hangs. General color translucent brown, the warts now being darker than the body. Anal tails positioned at either side of twig. Time, one day.



Figs. 8-14. *Prepona omphale octavia* Fruhstorfer: 8-10, pupa—lateral, dorsal and ventral views (3.2 cm long); 11-12, adult male—dorsal and ventral view (7 cm); 13-14, adult female—dorsal and ventral view (8 cm).

**Pupa.** Leaf green. Very humped dorsally across the first abdominal segments, tapering to cremaster and to head. Spiracula brown, with prominent orange stain around first abdominal one. Occasional orange stains in wing cases near antennae. Cremaster light brown and bifid head points light orange. Becoming dark gray shortly before adult emergence. Measures 3 to 3.3 cm long, 1.3 to 1.7 cm dorso-ventrally at widest point and 1.2 to 1.6 cm laterally at widest point. Time, 12–14 days.

**Adult.** Dorsally, basic color is dark gray to dark grayish brown. Forewing with iridescent light blue band that starts near costa subapically, with outer border parallel to wing's outer margin, inner border of band sinuose and diverging from outer border, so as to make band at inner margin of wing much wider than at costal margin. Hindwing with similarly colored band not reaching the costal margin, nor the outer angle, extending itself down parallel to the outer margin, but not reaching the anal angle, covering discal area without touching the inner margin or the basal area. Males, in addition to the light blue band in the forewing, have a dark blue area that covers the space between the band and the base of the wing. In the hindwing males have basally, under the cubital vein, a tuft of honey-colored "hairs." The females lack the dark blue area in the forewing, and have an "eye" near the anal angle in the hindwing.

Ventrally, wings are pearly gray basally, darker gray distally; the forewing with thin black lines forming an elaborate pattern, that in the hindwing is less elaborate. The hindwing has two medium-sized "eyes," dark colored and surrounded by a clear gray ring; one near the outer angle, the second corresponding to the eye seen dorsally in the female, near the anal angle. Basic color and markings are darker in males than in females.

Both sexes have the proboscis pink, the antennae black. Females have a wing span of 8 cm, while males are only 7 cm. Total developmental time: from 79 to 97 days, females being slower than males.

### Natural History

The foodplant, *Andira inermis* (Wright) Urban, is a robust leguminous tree that has very thick, dark green, imparipinnate foliage, with leaves ranging from 6 to 10 cm. long, and a profuse lilac inflorescence from early March to mid-April. It has a rounded tree-top, and has been favored as an ornamental tree alongside sidewalks and parks in towns. In natural conditions it usually grows near rivers, thence its local name: Almendro de Río (River Almond). These trees shed all their leaves from late December to late January, stay bare for about two weeks before growing new leaves that take another two weeks to reach maturity. After that, the trees flower.

Soon after the first instar larvae come out of the egg, they eat the egg shell completely, and stay under the leaf without further eating for one day. They move then to the tip of the leaf and eat around the central vein, leaving it bare. With frass stuck with silk they build a continuation to the bare vein, that then appears to project beyond the leaf limits, and the larvae keep perched on it while not feeding, usually head pointing outwards. This behavior is kept all through the first, second and third instars. Commonly during the third instar a larva

moves to another leaf because it has eaten the first one, and builds another "perch" on it with the now heavier frass. During the fourth stadium the larvae start wandering about the tree for feeding purposes, and keep motionless for long periods of time when not feeding, striking two characteristic poses: (1) head and thorax hanging at side of the twig where larvae hold with just the central prolegs, with the rear section of the abdomen either hanging also, or slightly raised from the seventh abdominal segment caudad; (2) head and thorax raised from second thoracic segment anteriad and last abdominal segments from seventh also raised. During the fifth stadium the larvae behave similarly. When newly hatched, and more markedly during subsequent stadia, the larvae walk with a balancing movement from side to side, due possibly to the very humped back and the fact that the reduced anal prolegs are not used for holding to the twigs while walking, having thence little leverage. During the prepupal stage, larvae weave a narrow girdle around a twig and then hang from it with the much reduced anal prolegs, positioning the crooked anal tails one at either side of the twig. Before hanging, the larvae clean the digestive tract by expelling a considerable amount of liquid with excrement. When becoming a pupa the larval skin splits from the head, breaking the head capsule in half and separating the fused horns. The larval attitude is all along very passive, being slow moving. No defense movements have been noticed during the pupal stage either, even when handled. Adults emerge very rapidly from the pupa shell, eject an amount of brown meconium, and are ready to fly in about 20 minutes.

The adults of *P. o. octavia*, like most Charaxinae, have a swift and powerful flight that produces a rustling noise, somewhat like Hesperidae. This flight has been described by Lichy (1962) ". . . algo ruidoso y con movimientos de alas perceptibles, aunque rapidísimos," (somewhat noisy and with perceptible wing movements, even though extremely swift). Males are very belligerent and chase any flying animal or object near their perching site. Females are larger than males and when ovipositing, circle the host tree several times at different levels before alighting in a cluster of mature leaves. There, sitting on the lower surface of the leaf, she deposits one egg. The female repeats the process several times before moving to another tree. The eggs we saw being laid were between 2.5 and 3.5 m. above the ground, the tree being about 6 m. tall. The hour, 13:15.

Both sexes are assiduous visitors of fermenting fruits, and some individuals have been observed feeding in specific spots on trees, halfway up the trunks. Both sexes favor shaded coffee plantations, ravines, and

rivers with thick second growth forests and patches of thick vegetation along shorelines.

It was noticed that when newly emerged males and females were pressed on the thorax, they emitted a light green liquid from the base of the wings, and that they produced a mouldy odor when handled.

We did not find a single case of parasitism in the 24 individuals observed. We found one instance of predation, a *Chrysopa* larva attacking a 2nd instar larva of *Prepona o. octavia*, which was killed without making any defense effort. The remains of a pupa were found still attached to a twig, only the abdominal segments affixed to the cremaster, with some body tissues left inside. One larva died while moulting to 2nd instar and one 4th instar larva died of a disease that softened the body.

Three adult females were dissected, one each on days one, two and three after emergence. No eggs were found in any of them. A bright green fluid was found inside the abdomen.

### DISCUSSION

As this is the first time the life cycle of *P. o. octavia* is fully described, some interesting facts have been found. The egg shape is very similar to the egg shape of the various species of *Anaea* found in El Salvador, even though its size is much bigger. The shape of the larvae from the 2nd stadium on resembles the shape of the larvae of *Anaea* (*Zaretis*) *ityis* Cramer (ms in prep.). The behavior of the three initial instars of *P. o. octavia* is very much like the behavior of those instars in various *Anaea* spp. except for the balancing gait of *Prepona* while walking. The spiracula of the 2nd abdominal segment in *P. o. octavia* is located very high, and this would explain why in the drawing of another *Prepona* (*P. amphimacrus* Fabricius) that appears in Comstock (1961, p. 174, fig. 234), this spiraculum is lacking. This same characteristic, not so drastic, is found in the various *Anaea* spp. larvae we have observed, as is the slightly out-of-line spiraculum on the 8th abdominal segment. All of these factors seem to confirm the grouping of the two genera under one subfamily: the Charaxinae.

The absense of parasitism found while breeding this species is striking considering the long developmental cycle (two and a half to three months), and the apparent lack of chemical and mechanical defenses. The larvae are very slow moving and passive, and the plant family Papilionaceae in general is not reputed for having poisonous components. Thus it appears that the immature stages of this species rely solely upon mimicry for protection: the larvae look like fragments of dry leaves, and the pupae are very inconspicuous in green foliage. It should be empha-

sized that while we studied the life cycle of *P. o. octavia*, the life cycles of two other species which were feeding on the same trees were being observed: *Panthiades bitias bitias* (Cramer) and *Theritas lisus* (Stoll) (both Lycaenidae). These two species produced braconid wasps most of the time. This fact excludes the explanation that the lack of parasitism in *P. o. octavia* was due to the absence of parasites at the time the life cycle was being studied.

A possible cause of massive mortality of young larvae during the dry season could be the characteristic of the host plant, *Andira inermis*, of shedding all of its leaves rather abruptly during the period between late December and late January (not all the trees shed their leaves at the same time). The trees remain bare of leaves for a couple of weeks before growing new ones, and it is another two weeks before the new leaves reach the maturity the larvae require for feeding. In natural conditions *A. inermis* trees grow too far away from one other to allow larvae to move from one tree to another. Even when planted as ornamentals along sidewalks and parks in towns, they are placed from 6 to 10 m. apart.

It is possible that *P. o. octavia* uses other plants of the same group as a food plant, although we have not observed this. We can say in any case, it is one of the few species of Rhopalocera that have profited by man-made changes in natural ecology.

According to the time it took to develop under laboratory conditions, we can assume that there are four generations a year of *P. o. octavia* in El Salvador. We can expect also that the females are slow in reaching sexual maturity, and that even if they produce eggs for a considerably long period of time (as do some other Lepidoptera with slow developmental time), they would not produce a very large number of them, because individuals of this species are rather scarce in spite of the little, if any, parasitism and predation the species is subject to, on one hand, and the abundance of the foodplant on the other. These factors would tend to make the species very abundant if the females were highly fertile.

Besides three other species of *Prepona* found in El Salvador, that resemble very much *P. o. octavia*, there is an Apaturinae, *Doxocopa cherubina* Felder, that is superficially very similar to it. Whether or not these two species form a mimetic complex, we do not know. If they do, which is the model and which the mimic? The fact is that both species are very scarce locally and that circumstance would go against the tenet of accepted Batesian mimicry theory that requires the protected model to be more abundant than its unprotected mimic. The fact that *P. o. octavia* feeds on a tree that is not reputed to have poisonous properties would tend to eliminate the possibility of this resemblance being a Muellierian mimicry case.

## ACKNOWLEDGMENTS

We are grateful for the kind assistance of Dr. Lee D. Miller (Allyn Museum of Entomology) who identified the species mentioned, and made constructive criticism on the manuscript. We also thank Dr. Alexander B. Klots, for his encouragement to present the results of our work, and Drs. Theodore D. Sargent and Allen M. Young, who gave many valuable suggestions. My younger son, Pierre, first observed oviposition in *P. o. octavia*. Specimens of early stages and adults are deposited with the Allyn Museum of Entomology.

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## TWO NEW SPECIES OF PHYCITINAE FROM TEXAS, WITH DESCRIPTION OF TWO NEW GENERA (PYRALIDAE)

ANDRÉ BLANCHARD

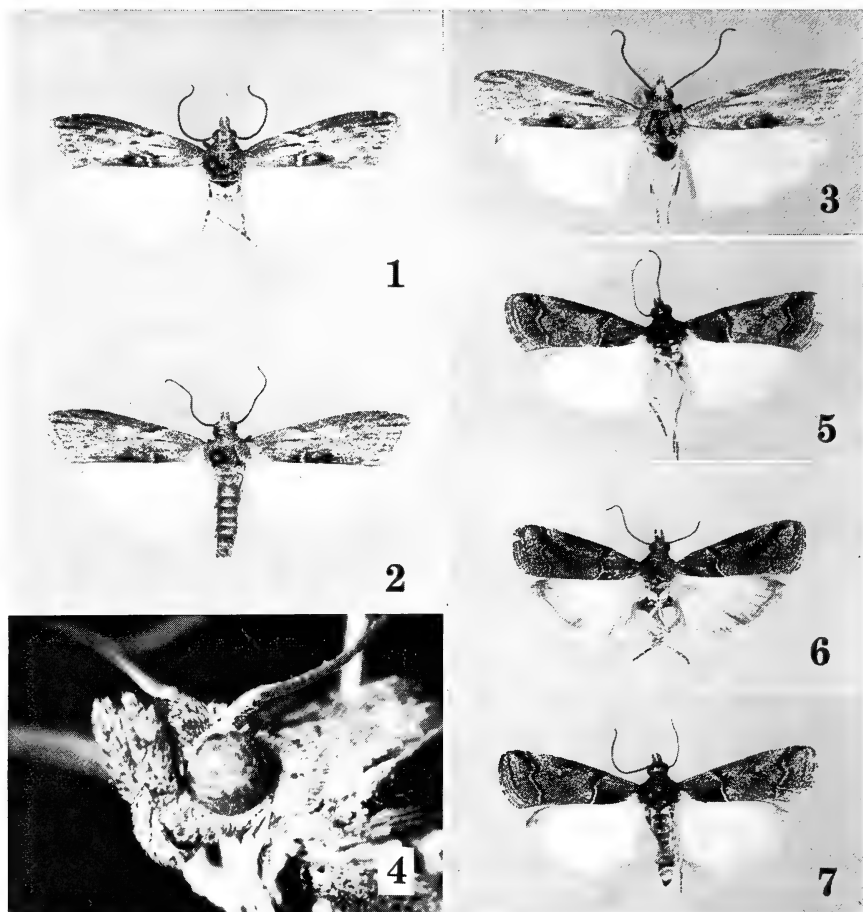
P. O. Box 20304, Houston, Texas 77025

### ***Triozosneura* A. Blanchard, new genus**

Tongue well developed. Antenna (Fig. 12) simple; finely pubescent in male. Labial palpus (Fig. 4) upcurved, rough scaled, reaching level of vertex, third segment very short (on denuded palpus (Fig. 13) it appears less than  $\frac{1}{3}$  the length of second segment). Maxillary palpus squamous. Vestiture entirely of scales.

**Forewing** (Fig. 11): Smooth, eleven veins,  $R_1$  absent, cell longer than half the length of the wing; discocellular vein weak curved; vein  $Cu_2$  from near lower angle of cell;  $Cu_1$  from the angle, slightly separated at base from stalk of  $M_{2+3}$ ;  $M_2$  and  $M_3$  stalked for about  $\frac{1}{3}$  their lengths;  $R_2$  contiguous or partly fused, for about  $\frac{1}{3}$  its length, with the stalk of  $R_{3+5}$ ;  $R_3$  and  $R_5$  stalked for about  $\frac{3}{4}$  their lengths; vein  $R_1$  from cell.

**Hindwing** (Fig. 11): With veins  $Cu_1$  and  $M_3$  both present; cell at lower angle about half as long as wing; discocellular vein deeply concave; vein  $Cu_2$  from near lower angle of cell; vein  $Cu_1$  shortly united with the stalk of  $M_{2+3}$ ;  $M_2$  and  $M_3$  stalked

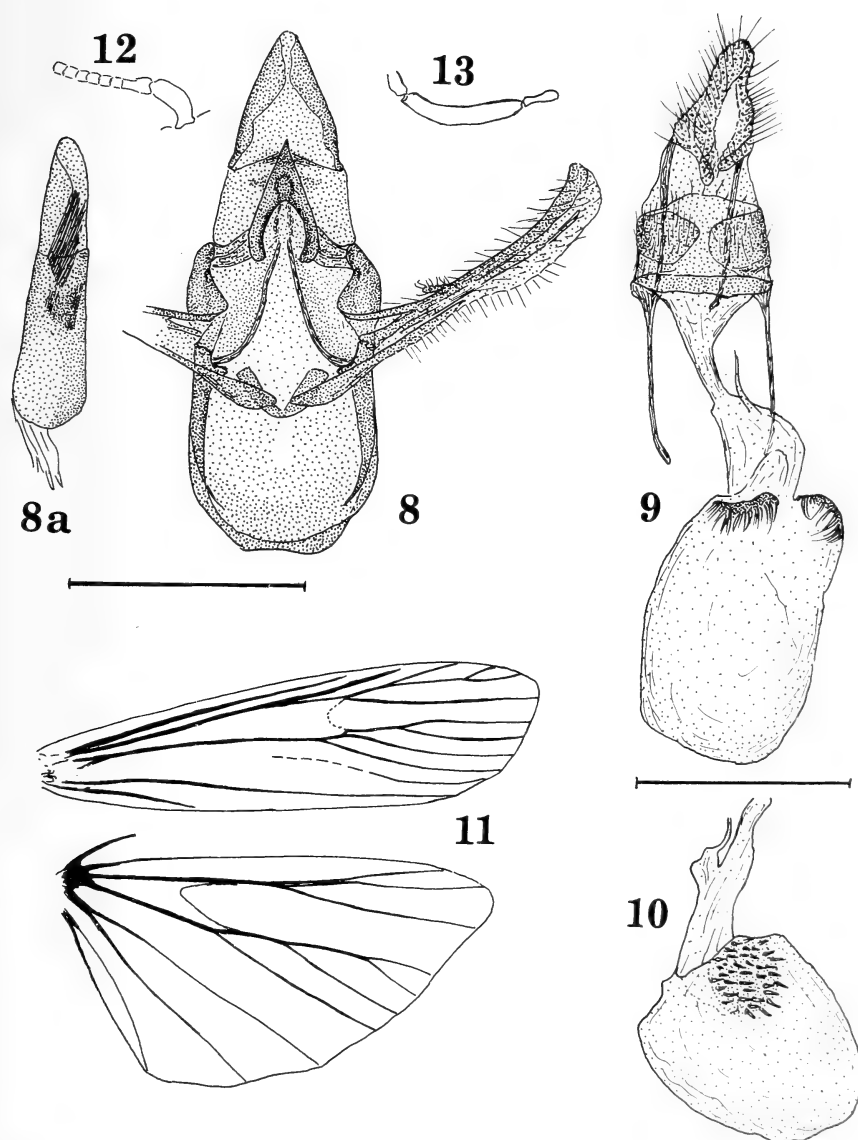


Figs. 1-7. Holotypes and paratypes. Figs. 1-4. *Triozosneura dorsonotata*: 1, holotype ♂, Mt. Locke, Davis Mts., 27 August 1970; 2, paratype ♂, Big Bend Nat. Park, Green Gulch, 31 March 1971; 3, paratype ♀, Big Bend Nat. Park, Green Gulch, 6 May 1972; 4, head of holotype. Figs. 5-7. *Glyphocystis viridivallis*: 5, holotype ♂, Big Bend Nat. Park, Green Gulch, 23 March 1971; 6, paratype ♀, Big Bend Nat. Park, Green Gulch 12 May 1972; 7, paratype ♂, Big Bend Nat. Park, Green Gulch, 28 March 1971.

for well over half their lengths;  $S_c$  and  $R_s$  shortly, and weakly anastomosed beyond cell.

**Male genitalia** (Figs. 8, 8a): Uncus hoodlike subtriangular; tegumen strongly sclerotized laterally from its junction with vinculum to midheight where it supports the lateral arms of the gnathos; gnathos hoodlike, with acute apex, deeply cleft dorsally, fused apically, with semi-elliptical ventral opening; valve narrow, unarmed, with strongly sclerotized costa; transtilla absent; juxta narrow embracing  $\frac{2}{3}$  of circumference of aedeagus; aedeagus half as long as combined height of vinculum, tegumen and uncus; vesica armed with a bunch of numerous cornuti, and what





Figs. 8-13. *Triozosneura dorsonotata*: 8, genitalia of ♂ holotype, aedeagus omitted (slide A.B. 2395); 8a, aedeagus; 9, genitalia of ♀ paratype (slide A.B. 3034); 10, bursa of ♀ paratype (slide A.B. 2909); 11, venation; 12, basal segments of antenna; 13, denuded left labial palp (inner aspect) of a damaged, discarded ♀ specimen (slides A.B. 2647A, 2647B).

appears as a small, thin, sclerotized membrane, bent as a half cylinder; vinculum about as broad as long.

**Female genitalia** (Figs. 9, 10): Genital opening simple, narrowly sclerotized ventrally; ductus seminalis from ductus bursae, midway between genital opening and bursa; bursa with two signa, each consisting of a disk armed with hollow spines. Figs. 9 and 10 represent the bursae of two different specimens. It is believed that the bursa of the former is over-inflated, whereas that of the latter, which is depressed all around the ductus bursae, thus forming a circular groove and a ridge, is more nearly normal. In Fig. 10 one signum only was represented for the sake of clarity: it is on the inner wall of the ridge and seen through the membrane of the bursa.

If and when other species of this genus are discovered some of the characters of this description will appear only of specific value, but it would be awkward to guess which ones at the present time.

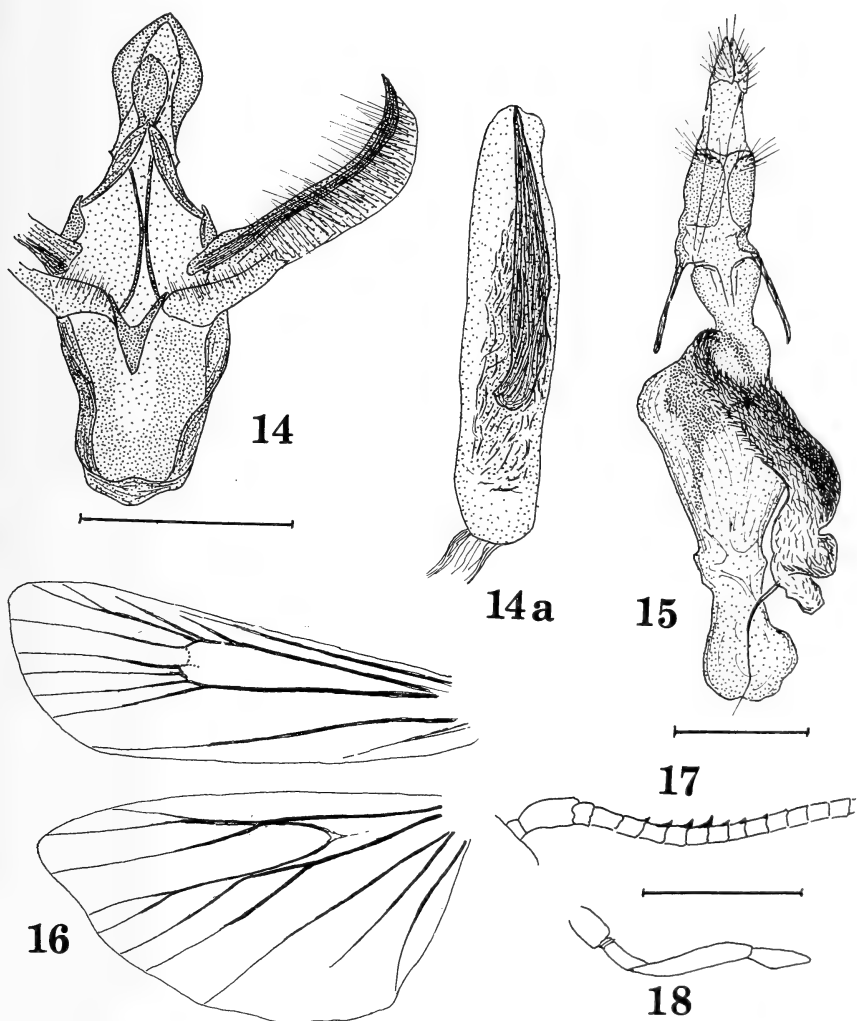
The venation of the hindwing makes *Triozosneura* a member of Heinrich's Group I and venetional division B. Using Heinrich's key for division B, we are led through couplets 1, 3, 8, 9, 16, 21, 22 and 24 to couplet 25 which offers two alternatives, none of which applies satisfactorily to the case at hand: 26 is eliminated because the transtilla is absent from the male genitalia, 27 because the ductus seminalis is from the ductus bursae in the female genitalia. Thus we are led to a dead end in which, by chance, there are only four genera, namely: *Coptarthria*, *Anadelosemia*, *Gabinius* and *Ceracanthia*. It is enough to examine the detailed description of these four genera, and the figures of the male and female genitalia of all species belonging to them, to convince oneself of the necessity of a new genus.

### ***Triozosneura dorsonotata* A. Blanchard, new species**

(Figs. 1, 2, 3, 4, 8, 8a, 9, 10, 11, 12, 13)

Head and thorax covered with gray or black scales tipped with white, more contrastingly mixed on the palpus. Abdomen yellowish gray. Forewing above gray, darker along costa, variably suffused with whitish on each side of the antemedial line, in the cell, and in the fold. Antemedial line white, starting on costa  $\frac{1}{2}$  distance from base to apex, reaching dorsal margin  $\frac{2}{3}$  distance from base to tornus, outwardly bilobed between (often indistinctly); contrastingly bordered with black outwardly, between costa and radius, where it is aimed toward tornus; widely, roundly excurved between radial and anal veins, where the black outer line almost disappears except for a conspicuous black spot on cubital vein, marking the notch between the two lobes; contrastingly bordered with black on both sides between anal vein and inner margin. Subterminal line mostly indistinct. Discal dots obsolete. On some specimens a reddish or yellowish diffuse spot covers the discocellular vein. Some veins are marked in black, particularly  $R_5$  and  $M_1$  and the cubital in the basal space. A black blotch beyond the middle of the inner margin is generally separated from the antemedial band by a paler spot. Terminal dots and line absent. Fringe gray, somewhat lighter than the background of the wing. Hindwing yellowish-white, a little darker along the outermargin, mainly in females; fringe concolorous with disk of wing. Beneath: forewing brownish gray, a little darker along costa, hindwing as above. Wing expanse: male 25 to 28 mm.; female 25.5 to 29 mm.

**Holotype:** Male, Davis Mountains, Mount Locke, McDonald Observatory



Figs. 14–18. *Glyphocystis viridivallis*: 14, genitalia of ♂ holotype, aedeagus omitted (slide A.B. 3030); 14a, aedeagus; 15, genitalia of ♀ paratype (slide A.B. 3028); 16, venation; 17, basal segments of antenna; 18, denuded left labial palp (inner aspect) of damaged discarded specimen (slide A.B. 2649).

Grounds, Texas 27 August 1970, genitalia on slide A.B.2395, deposited in the National Museum of Natural History (No. 72379).

**Paratypes:** Big Bend Nat. Park, Basin, 7 April 1967. 1♂, (A.B.627); Green Gulch, 25 March 1971, 1♀, (A.B.2909); 31 March 1971. 1♂; 6 May 1972, 1♀, (A.B.3034); 12 May 1972, 1♂. Davis Mts., 5 miles SE of Mt. Livermore, 29 August 1970, 1♀, (A.B.2396).

### **Glyphocystis A. Blanchard, new genus**

Tongue well developed. Antenna finely pubescent; on male with a shallow sinus at base of shaft, containing a row of minute black teeth half hidden between two rows of scales (Fig. 17). Labial palpus (Fig. 18) oblique, not grooved, smooth scaled, reaching level of vertex; third segment about  $\frac{1}{3}$  length of second, not projected forward. Maxillary palpus squamous, vestigial.

**Forewing** (Fig. 16): Smooth, with eleven veins; cell about  $\frac{3}{8}$  length of wing; discocellular vein concave and weak between veins  $M_1$  and  $M_2$ ; vein  $Cu_2$  from before the lower outer angle of cell;  $Cu_1$  from the angle, closer to  $M_3$  than to  $Cu_1$ ,  $M_2$  and  $M_3$  separated at base;  $M_1$  from below upper outer angle of cell, straight;  $R_3$  and  $R_5$  stalked for a little over half their lengths;  $R_1$  and  $R_2$  separately from cell.

**Hindwing** (Fig. 16): With veins  $M_3$  and  $Cu_1$  both present. Cell at lower angle about half as long as wing; discocellular vein deeply concave, considerably extended at lower angle; vein  $Cu_2$  from before angle;  $Cu_1$  from angle, connate to the stalk of  $M_{2-3}$ ;  $M_2$  and  $M_3$  anastomosed for about half their lengths;  $M_1$  connate to the contiguous parts of  $R_s$  and  $Sc$ , which is about the same length as the free portion of  $Sc$ .

**Male genitalia** (Figs. 14, 14a): Apical margin of uncus subrhomboidal; gnathos terminating in a spatulate hook; valve with strongly sclerotized costa, markedly produced at apex, about as long as combined length of tegumen and uncus; transtilla absent; juxta V-shaped; vinculum not quite as wide as long, becoming narrower and truncate anteriorly; aedeagus almost as long as combined length of vinculum, tegumen and uncus, stout; vesica armed with one stout cornutus, almost as long as aedeagus.

**Female genitalia** (Fig. 15): Genital opening simple; ductus bursae somewhat contracted and membranous at junction with bursa; bursa wide and sclerotized posteriorly, bulbous and membranous anteriorly, provided on its right side with a large lobe; most of the inner surface of the lobe, a collar around ductus bursae, and some of the dorsal surface of the bursa covered with an inner, densely spinose mat. Ductus seminalis from the anterior end of the lateral lobe.

In spite of the absence of a transtilla, and of substantial differences in the gnathos of the male genitalia, the following species could have been described in *Catastia*, but in view of considerable differences in the female genitalia this course of action was deemed inadvisable.

### **Glyphocystis viridivallis A. Blanchard, new species**

(Figs. 5, 6, 7, 14, 14a, 15, 16, 17, 18)

Head, collar, first and second segments of palpus clothed with dark gray, white-tipped scales; gray and white more contrasting on second segment of palpus, third segment acute, black. Thorax concolorous with background of forewing. Forewing background, a nearly uniform slate-gray produced by dark gray, white tipped scales; generally a little darker in basal space. Antemedial line whitish, outwardly bordered by a black line which is generally much wider between costa and cubitus than in fold; varying from almost straight to a little sigmoid (outwardly convex above  $Cu$ , concave in fold) starting on costa  $\frac{1}{4}$  distance from base to apex, reaching inner margin  $\frac{2}{5}$  distance from base to tornus; a dark blotch of variable extent adnate to and basad of am line, along inner border. Subterminal line whitish, inwardly bordered by a thin black line (thicker and darker near costa), roundly retracted on vein  $M_1$ , and again, but less so in fold, reaching tornus at base of some very long fringe scales. A black triangular blotch distad of, and adnate to s.t. line near apex. Fine terminal black line. Fringe long, light gray, consisting of scales of three

different lengths, tipped with darker gray. Hindwing pale yellowish-white, darkened near apex and, in the female, along outer margin. Beneath: forewing yellowish-gray, hindwing yellowish-white. Wing expanse: 21 to 24 mm.

**Holotype:** Male, Big Bend National Park, Green Gulch, Texas, 28 March 1971, gen. prep. A.B. 3030, deposited in the National Museum of Natural History, (No. 72380).

**Paratypes:** All from Big Bend Nat. Park, Green Gulch: 9 October 1969, 1 ♂, (A.B. 2011); 28 March 1971, 5 ♂♂, (A.B. 3030, 2649, 2650); 3 May 1972, 1 ♀, (A.B. 3029); 12 May 1972, 1 ♂, 1 ♀, (A.B. 3028).

#### ACKNOWLEDGMENTS

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### NOTES ON THE TAXONOMIC STATUS OF *HYALOPHORA COLUMBIA* (SATURNIIDAE)

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The work of many authors (Sweadner, 1937; Weast, 1959; Collins & Weast, 1961; Wright, 1971) has shown that the various forms of *Hyalophora* are not reproductively isolated from one another. Females of any form of *Hyalophora* (in the restricted sense of Ferguson, 1972) will attract and mate indiscriminately with males of any other form. Generally ova laid by cross-mated females are viable and usually produce fertile F<sub>1</sub> males and sterile females. Backcrossing the F<sub>1</sub> male with a female of either parental form or even a third form again produces fertile males and generally sterile females. Occasionally these females may lay some fertile ova.

Intergrades and hybrids occur in nature. A population currently designated "*kasloensis*" (Cockerell) exists between *H. gloveri* (Strecker) and *H. euryalus* (Boisduval) in Idaho, western Montana, and British

Columbia and is believed to be an intergrade between these two forms. *H. cecropia* (Linnaeus) produces occasional hybrids with *gloveri*. I obtained such an individual when a hybrid-like cocoon collected along with typical *gloveri* in the Black Hills of South Dakota produced a female very similar to laboratory hybrids. Mr. Duke Downey (pers. comm.) has collected supposed hybrids in Sheridan, Wyoming, but only rarely. The contact between *gloveri* and *cecropia* may be the recent result of a westward invasion of the latter species (Cockerell, 1929; Peterson & Worden, 1962).

Wild hybrids between *H. columbia* (Smith) and *cecropia* have been cited by Sweadner (1937). I collected a hybrid male along with typical *columbia* one mile west of Whiteshell Provincial Park along Highway One in Manitoba on 18 June 1963. This specimen will be described in a later paper. No true blending occurs between *cecropia* and the other forms but introgression is indicated by *columbia* and *gloveri* specimens with red scales in the extradiscal band. About half the specimens of *gloveri* and *columbia* sampled by Sweadner in areas of contact with *cecropia* exhibited this trait. The density of recognizable hybrids in nature is lower than predicted from the results of laboratory crosses. In addition, the mobility of the males during the mating flight and of the females during oviposition assures a potentially high rate of gene flow. Selection must act strongly against hybrids in some way. Hybrids may be ill-adapted such as in oviposition habits and consequent foodplant acceptance. *H. columbia* spins a small cryptically colored cocoon on exposed tamarack branches. When *cecropia* breeds with this form the larger non-cryptic hybrid cocoon may be more easily found by predators.

Given the ability of the *Hyalophora* forms to intergrade, the origin and present status of *columbia* seemed to be an excellent subject for study. In the United States *gloveri* is quite distinct phenotypically and is separated geographically from the small dark form in Maine, Wisconsin, and Michigan designated *columbia*. In western Canada the *gloveri* population exhibits a phenotype nearer to *columbia* in size but often even more brightly colored than the Rocky Mountain phenotype. Consequently, *gloveri* and *columbia* have up to now been considered separate species. On the basis of geographic distribution, wing pattern, and identical genitalic structure, Sweadner believed *columbia* arose from *gloveri* at the end of the last period of glaciation. To account for the apparent lack of intergradation, he believed the two became geographically isolated by foodplant preference. The *gloveri* population in the prairies of Alberta, Saskatchewan, and Manitoba, which has been given the subspecies name *nokomis*, feeds on wolf willow (*Shepherdia*) and to a lesser extent on willow (*Salix*). The *Hyalophora* in the swamps east of Winnipeg,

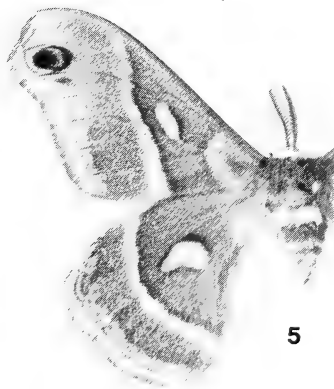
recognized as *columbia*, is thought to feed entirely on tamarack (*Larix*). These food plants are not isolated, however. The *Shepherdia* of the plains meets to the north a broad band of spruce-tamarack forests ranging from British Columbia across Alberta and Saskatchewan to Manitoba where the conifers dip south to the east of Winnipeg (Harlow & Harrar, 1949). Thus, a foodplant bridge connects the two populations but at a more northern point than was sampled by Sweadner.

### Field Work

I conducted field research in Canada in 1963, 1964, and 1966 to better sample these populations. Tied females and females in specially designed moth traps were placed at intervals throughout selected areas. The moth trap consists of a nine inch metal funnel mounted at one end of a screen cylinder two to three feet high. A small cage is suspended above the mouth of the funnel and confines a *Hyalophora* female. Attracted males, in their frenzy to reach the female, eventually collide with the funnel and slide through its enlarged opening. Thus, several males can be taken at each site and the female can be used as bait for up to 4 or 5 days.

Three population areas were sampled. The general trap line was along Highway One east and west of Winnipeg. The small dark phenotype was first taken just outside of the tamarack bog 30 miles east of Winnipeg near Richer. Thirty-two specimens were taken at regular intervals up to the Manitoba-Ontario Border beyond which no traps were placed. No males of any form were collected beyond the western extent of the bog 30 miles east of Winnipeg to a point 90 miles west of Winnipeg. *Shepherdia* does not seem to occur in this immediate area and extensive farming must further isolate the two *Hyalophora* forms. Stands of *Shepherdia* occur west of here along fence rows and in untillable terrain. To the west the first male of the brightly colored phenotype was taken 26 miles east of Brandon, Manitoba. A total of 17 specimens was taken westward along Highway One to Swift Current, Saskatchewan. The only *cecropia* collected was trapped 5 miles west of Virden, Manitoba on 21 June, 1963.

In an attempt to collect a predicted intermediate form between *gloveri* and *columbia*, I collected north along Highway Ten to Flin Flon, Manitoba and then west to Prince Albert Park, Saskatchewan. The terrain near Flin Flon is unusual in that the tamarack bog is interrupted by granite outcroppings and the flora is consequently more varied. *Shepherdia* was not seen near Flin Flon. The possible implications of this environmental change was discussed below. Frequent cold weather limited collecting but 12 males were taken from 17 to 22 June, 1964.





### Analysis of Specimens

When the population samples collected were compared superficially, it was clear that not all specimens could be placed into one of two distinct phenotypes. Furthermore, the light and dark moths were not always associated with the expected foodplant community. One of the males from the tamarack bogs east of Winnipeg was as brightly colored as the average *Shepherdia*-feeding phenotype and at least one of the specimens from the latter population was quite as dark as those from east of Winnipeg. Sweadner reported similar specimens from the large samples he secured.

The moths taken from the north were quite variable; some were as dark as those from east of Winnipeg and others were as bright as the prairie phenotype. Most were intermediate in coloration (Fig. 1). To present a more objective comparison, I quantified this color variance and analyzed it statistically. While the more northern sample was somewhat small, I believe the results are significant. The ground color of the dark phenotype is usually accompanied by a darkening of the color band distal to the white wing band. Under the microscope one sees that this darkening is the result of an increase in the number of black scales relative to the number of white scales. Using a magnification of 40 $\times$  with a grid reticle I measured the relative scale density in this band contained in the cell formed by veins Cu<sub>1</sub> and M<sub>3</sub>. The total numbers were converted to percentages and then plotted as a distribution with the mean and standard deviation. Fig. 2 shows that the specimens from northern Manitoba are more variable than those from east of Winnipeg and are very intermediate for this character.

Surprisingly, the moths from northern locales were larger on the whole in both average and maximum size than specimens taken further south. Males collected east of Winnipeg (32 specimens) averaged 50.3 mm measured from point of attachment of the forewing to the apex. These specimens ranged from 45.0 to 54.0 mm. Moths collected from 250 to 375 miles NW of Winnipeg (12 specimens) averaged 55.8 mm and ranged from 50.0 to 61.0 mm. The prairie sample (17 specimens) averaged 52.2 mm and ranged from 48.0 to 55.0 mm.

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Fig. 1. Extreme light and dark specimens for each population area: *H. columbia*: 1, Manitoba, 8 mi. e. Richer, 18 June 1966; 2, Manitoba, 17 mi. e. Richer, 18 June 1966. Intermediate *Hyalophora*: 3, Manitoba, 3 mi. s. Baker's Narrows, 21 June 1964; 4, Saskatchewan, 80 mi. w. Flin Flon, Ballantyne Bay, 22 June 1964. *H. gloveri nokomis*: 5, Manitoba, 3 mi. e. Brandon, 17 June 1966; 6, Manitoba, 5 mi. w. Virden, 21 June 1963.

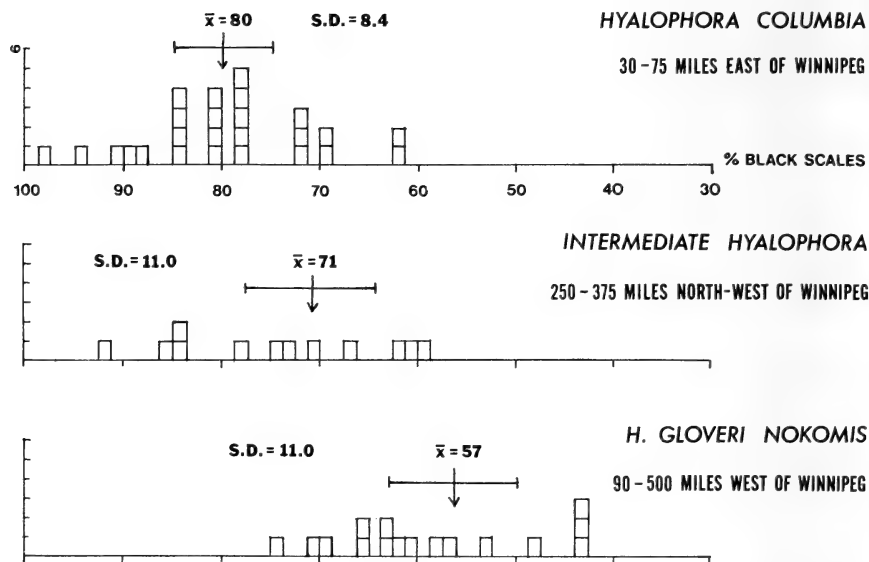


Fig. 2. Comparative scale counts of specimens collected in the three population areas. Scales were counted in a cell of the grey band of the FW formed by veins  $Cu_1$  and  $M_3$ .

After a thorough examination, I am in agreement with Ferguson (1972) that there are no significant structural differences, including genitalic characters, between *gloveri nokomis* and *columbia* adults. As with the adults, the larvae of these two forms differ mainly in size and coloration. I have reared over 100 *gloveri* larvae from north central Montana and found 25% to exhibit up to the fifth instar the same black dorsal and lateral scoli seen in immature *columbia* larvae. In the last instar the *columbia* larva differs from *gloveri* mainly in the color of the enlarged dorsal tubercules on segments 2, 3, and 4; these scoli vary from dull red-brown to a brighter red and are encircled at their bases by black. In *gloveri* these same scoli are usually yellow with a reduced black basal ring. I have seen a larva from Sheridan, Wyoming which possessed dull orange thoracic dorsal scoli. The remaining dorsal and lateral scoli are nearly identical in both *columbia* and *gloveri*; those on the sides vary from light blue tipped with white to nearly all white while the dorsal scoli on the abdominal segments are pale yellow. I have reared a few Montana (Toole Co.) *gloveri* which possessed yellowish orange dorsal scoli. Published descriptions of fifth instar *gloveri* larvae are varied. Sweadner (1937) states that all the dorsal scoli are straw yellow, "but in a few exceptions those on segments two, three, and four are slightly deeper in shade." He further mentions a larva from Glacier National

Park, Montana with the dorsal scoli on segments 2 and 3 colored a "dull burnt orange." Cooley (1908) reared *gloveri* larvae from Bozeman (Gallatin Co.), Montana and described the dorsal scoli on segments 2 and 3 as "coral red" in color. Few descriptions of the *gloveri nokomis* larva have been published but Freedley (1908) describes the dorsal scoli as all yellow in Alberta specimens. Thus it appears that while *columbia* larvae are rather constant in coloration, a certain percentage of fifth instar *gloveri* larvae possess reddish dorsal scoli on segments 2 and 3 and the immature larvae of both forms may be nearly identical except for size. Mature hybrid larvae of *columbia*  $\times$  *gloveri* may exhibit either all yellow or all red dorsal scoli on segments 2, 3, and 4. The cocoons of *gloveri nokomis* and *columbia* are said to be indistinguishable.

#### Laboratory Breeding

The results of interbreeding were limited by the high rate of disease present in all my *Hyalophora* larvae, including pure strains. Nevertheless, two female adults were reared on *Larix* from a mating between a female from Montana (Toole Co.), and a male taken 58 miles east of Winnipeg. Both of these females appeared fully fertile and laid a normal compliment of ova when bred to Montana *gloveri*. No exact count was made of the number of ova laid or the percentage of hatch but approximately 90% of the ova produced larvae. The resulting larvae were unfortunately lost to disease. More recently, hybrids between *columbia* (Livingston Co., Michigan) and *gloveri* from western Utah were reared by Mr. James Tuttle and Robert Weast. Two pairings of a male *columbia*  $\times$  female *gloveri* yielded 92% and 90% hatch of ova laid. The reciprocal cross produced an 89% and 61% hatch (James Tuttle, pers. comm.). Robert Weast (pers. comm.) succeeded in inbreeding the F<sub>1</sub> hybrids of *gloveri*  $\times$  *columbia*; the three females laid an average of 150 ova each. This is a normal number for the smaller *Hyalophora* forms. Fertility was over 90%. The results of this and future crossbreeding should be quantitatively compared to the degree of fertility seen in crosses involving other forms, such as *gloveri*  $\times$  *euryalus*. Furthermore, it should be determined if the fertility between *gloveri* and *columbia* changes as a function of geographic (and ecologic) separation of the populations studied.

Some new information is available on the conifer feeding habits in the *Hyalophora*. In 1963 I reared to maturity on *Larix* two normal *gloveri* from a Russian Olive feeding population in Montana. Two dozen larvae were initially started successfully on *Larix* but again disease disrupted the experiment. In England *gloveri* is reported to be commonly reared on European Larch (Crotch, 1956). Dr. Thomas Koerber of the U.S.

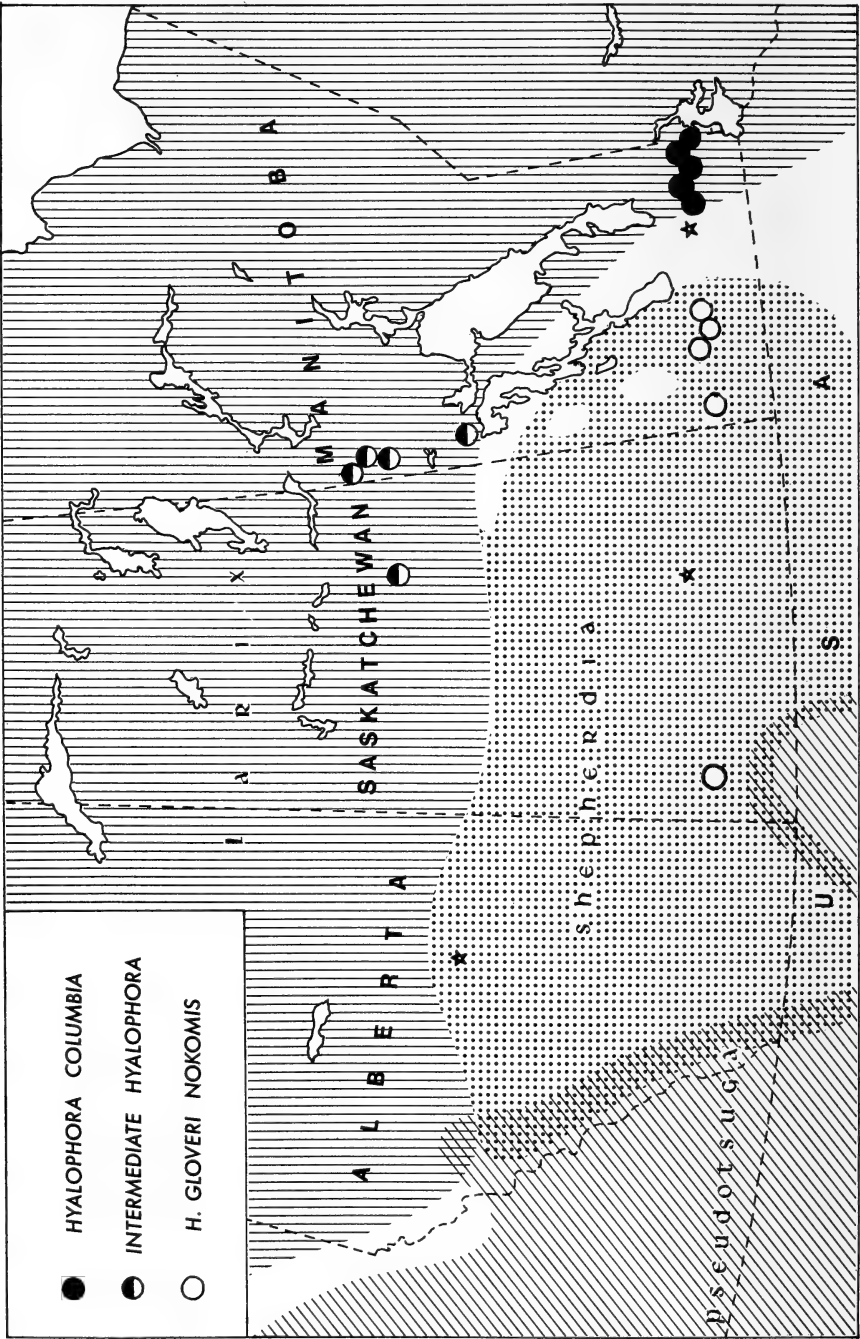


Fig. 3. Collection sites, with the approximate distribution of food plants (based partly on Harlow & Harrar, 1949).

Forest Service has collected wild *euryalus* larvae and cocoons on Douglas Fir (*Pseudotsuga*) at several locales in the Klamath and Cascade Mountain ranges of northern California. We have both reared *gloveri* and *euryalus* on Douglas Fir in captivity. A more detailed discussion of this work will be published at a later time. I am at present rearing thirteen *columbia* larvae which I have found will switch in the fifth instar from *Larix* to *Pseudotsuga* after 30 to 45 minutes hesitation. During the first instar five larvae of a total of 24 initially began feeding on *Pseudotsuga* but eventually wandered to nearby *Larix* twigs. I did not force any of the first instar larvae to feed on *Pseudotsuga* due to the present scarcity of *columbia* stock. I feel that the ability of the various *Hyalophora* to feed in captivity on conifers, even reluctantly, is especially significant when one considers that many rather monotypic species, such as *Callosamia promethea* (Drury), may be regionally quite food plant specific (Collins & Weast, 1961). One would expect the acceptance of conifers to decrease outside the normal range of these food plants.

### Conclusion

Gene flow between the brightly colored prairie population and the population of dark moths in the tamarack bogs east of Winnipeg produces in each population occasional phenotypes similar to the opposite form. The variability in the northern population of intermediates is also the result of gene flow from the two extreme populations. This clinal variation seems not to be any more sudden in the sense of a "step cline" than is the transition from the Rocky Mt. phenotype into the bright prairie form. Both clines involve phenotypic and foodplant changes.

Selection must favor the dark phenotype in the tamarack bogs and the lighter form in the prairie region since on the average the two populations have rather distinct phenotypes. North of Winnipeg the environment undergoes a transition from plains to conifer forest. Perhaps here where the intermediate form occurs, selective forces do not clearly favor either the light or dark phenotype, thus promoting the rate of gene exchange. See Fig. 3 for food plant distribution and collecting sites.

Melanism in other Lepidoptera has been shown to be controlled by a relatively few alleles. Thus, while the dark phenotype described as typical of *columbia* may appear to be qualitatively different from *gloveri*, the genetic basis for the apparent differences is probably minor. Whether this melanism is directly adaptive or is somehow linked with other adaptive gene systems is unknown.

The conifer feeding habit has been shown to not be restricted to *columbia* and may even prove to be widespread in the western forms. Workers should attempt to determine if "*kasloensis*" and *gloveri* feed

naturally on either Douglas Fir (*Pseudotsuga*) or Western Larch (*Larix occidentalis*) in the Bitterroot and Rocky Mountain ranges.

The selective basis for the melanism seen in *columbia* may operate during the larval stage. Perhaps the darker *columbia* larva is more cryptically colored in comparison to the lighter *gloveri* larva when feeding on the sparsely needled *Larix*. The immature *columbia* are especially difficult to locate when reared in sleeves on larch. If the genes controlling melanin production in the larva are somehow linked with those controlling scale pigmentation in the adult, predator selection would quickly produce dark adults while acting upon the larval stage. Admittedly, such a gene system would be exceptional. Larvae are subject to much greater predation pressure than the short-lived nocturnal adults, however. The "ecological image" of the adults is the underside of their wings as they rest with their wings folded over their backs. Furthermore, *euryalus*, *gloveri*, and *columbia* are much more similar when viewed in this aspect. Thus, the visual variance in dorsal wing coloration may not be the result of selection for this characteristic *per se*. Selective breeding for light and dark larvae and adults may reveal a correlation.

In summary, the obvious similarity of the two forms in all stages, the clinal variation of the melanization of the adults, and the demonstrated lack of isolation mechanisms coupled with the fertility seen in hybrid females all suggest *columbia* is not a separate species but is rather a melanic subspecies of *gloveri*. It is hoped that this paper will encourage and aid further investigation.

#### ACKNOWLEDGMENTS

I would like to sincerely thank Dr. C. Don MacNeill for continued help in the conception and analysis of the research project and in preparing this paper. I am also grateful for the living material and breeding information kindly provided by James Tuttle and Robert Weast.

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## NOTES ON *SIPROETA* AND *METAMORPHA* WITH FIGURES OF *SIPROETA EPAPHUS GADOUI* MASTERS (NYMPHALIDAE)

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*Siproeta epaphus gadoui* Masters (1967) was described from a series of specimens collected by Albert and Mary Lou Gadou at El Pao, Bolivar, Venezuela. The subspecies is of particular interest because it is intermediate in many respects between *S. epaphus* (Latreille) and *S. trayja* Hubner, which have been considered to be distinct species in the past. *S. gadoui* appears to be derived from *trayja* stock rather than from the geographically adjacent *epaphus*, although the entire Amazon Valley now separates *trayja* and *gadoui*. The description of *gadoui* was hurried in order to make the name available for a genus revision by Richard M. Fox and Alden C. Forbes and the new subspecies was not figured. The original description did promise figures in the coming revision of Fox & Forbes. The senior author of this revision, R. M. Fox, died on 25 April 1968 with the manuscript partially completed. F. Martin Brown completed the manuscript which was finally published on 24 December 1971, albeit without figuring *gadoui*. I feel that it is important to figure this interesting butterfly and figures are hereby presented (Fig. 1).

The Fox & Forbes revision (1971) may not be readily available to all lepidopterists and a summary may be useful. The genus *Metamorpha* was divided into two genera: *Metamorpha* Hubner (type species *elissa* Hubner), and *Siproeta* Hubner (type species *trayja* Hubner). Differences were cited in venation (in *Metamorpha* a vestige of the posterior tip of the third discocellular is present on the forewing), male forelegs (in *Siproeta* the tarsus is little more than half the length of the tibia, in *Metamorpha*

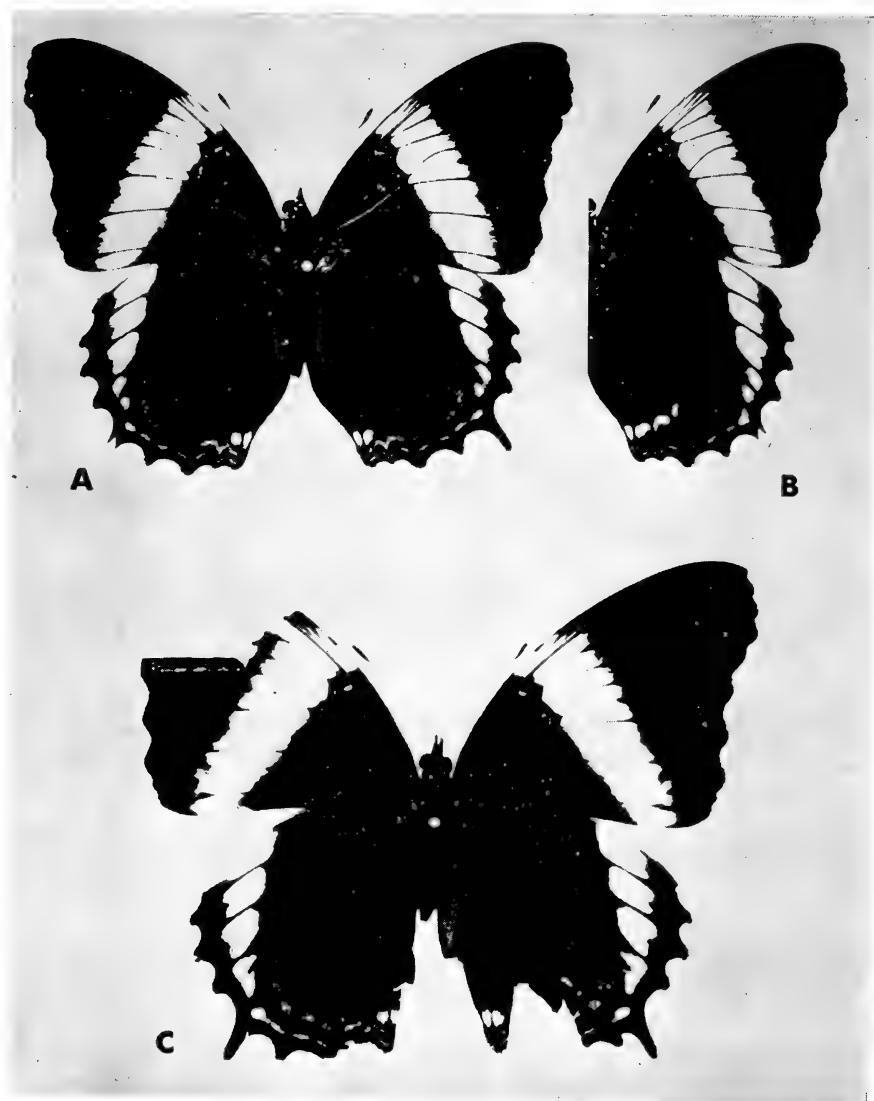


Fig. 1. *Siproeta epaphus gadoui* Masters: A. holotype male, El Pao, Bolivar, Venezuela; B. same, underside; C. allotype female, El Pao, Bolivar, Venezuela, upperside. All specimens natural size.

it is one-fourth the length), and male genitalia (in *Siproeta* the tegumen and uncus are still separated by a suture, but in *Metamorpha* the suture has been lost and they are fused). A checklist of species and subspecies follows:



- 1.1 *Siproeta epaphus*  
 a. *S. e. epaphus* (Latreille) 1811 Mexico to Bolivia, eastward into northern Venezuela. Only known from El Pao, Bolivar, Venezuela. Southern Brazil and Paraguay.  
 b. *S. e. gadoui* Masters 1967  
 c. *S. e. trayja* Hubner 1823
- 1.2 *Siproeta superba*  
 a. *S. s. superba* Bates 1864 Southern Mexico, Guatemala and Honduras. Costa Rica.  
 b. *S. s. euoe* Fox & Forbes 1971
- 1.3 *Siproeta stelenes*  
 a. *S. s. biplagiata* (Fruhstorfer) 1907 All of Central America, northern Colombia, southern Texas and Cuba. Jamaica, Hispaniola, Cayman Islands, Virgin Islands, Leeward Islands, etc. Trinidad and all of South America excepting northern Colombia and western Ecuador. Western Ecuador.  
 b. *S. s. stelenes* (Linnaeus) 1758  
 c. *S. s. meridionalis* (Fruhstorfer) 1909  
 d. *S. s. sophene* (Fruhstorfer) 1907
- 2.1 *Metamorphia elissa*  
 a. *M. e. elissa* Hubner 1919 Colombia to Peru and throughout the Amazon Valley. Eastern Bolivia.  
 b. *M. e. pulsitia* Fox & Forbes 1971

The only effect upon the Nearctic fauna is that *Metamorphia stelenes*, species number 524 in the Dos Passos (1964) checklist, should be placed in the genus *Siproeta*.

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 MASTERS, J. H. 1967. A new *Siproeta* (Lepidoptera: Nymphalidae) from Venezuela. Ann. Carnegie Mus. 39: 193-194.

#### NEW FOODPLANT RECORDS FOR *PAPILIO POLYXENES* F. (PAPILIONIDAE)

That the larvae of *Papilio polyxenes* F., the eastern black swallowtail butterfly, feed solely on plants of the carrot family, the Umbelliferae, is well documented (e.g., Scudder 1889, The Butterflies of the Eastern United States and Canada II; Holland 1931, The Butterfly Book; Dethier 1941, Amer. Nat. 75: 61-73; Forbes 1960, Lepidoptera of New York and Neighboring States IV). The following three umbellifers have not previously been reported as larval food plants for this species.

On 1 June 1970, at the summit of Shaw's Ridge, Highland County, Virginia, I found two *P. polyxenes* larvae feeding on a meadow parsnip, *Thaspium barbinode* (Michx.) Nutt., which was growing in company with golden alexanders, *Zizia aptera* (Gray) Fern., on a dry roadside bank along Route 250. I reared the larvae to

pupation on *T. barbinode* and *Z. aptera* collected at that site and on *Pseudotaenidia montana* Mackenz., mountain pimpernell, gathered at the summit of Shenandoah Mountain along the same route. Both larvae had been parasitized, and wasps, *Trogus pennator* (F.), emerged from the chrysalids on 18 June 1970.

Identifications of the plants were kindly verified by Dr. Peter Hyypio, L. H. Bailey Hortorium, Cornell University, and plant specimens have been deposited in the Herbarium. The identity of the chrysalids was verified by Dr. John G. Franclemont, Department of Entomology, Cornell University, and the parasites were identified by Dr. Robert W. Carlson, Systematic Entomology Laboratory, USDA, Washington, D.C. Insect specimens have been deposited in the Cornell University Collection, Lot 1023, Sublot 16a.

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#### A YELLOW ABERRATION OF *LERODEA EUFALA* (HESPERIIDAE)

Four of the five commonest, most widespread Hesperinae in the Central Valley of California are golden-yellow in color: *Hylephila phylaeus* (Drury), *Atalopedes campestris* (Bdv.), *Polites sabuleti* (Bdv.) and *Ochlodes sylvanoides* (Bdv.). The fifth, *Lerodea eufala* (Edw.), is dark brown with a few small whitish spots on the forewing above and below. On 4 September 1972, a male *L. eufala* was taken at Willow Slough, Yolo County, California, in which the dark brown is completely replaced by golden-yellow of nearly the exact shade prevalent dorsally in *O. sylvanoides*. The replacement extends to the body, appendages, and both wing surfaces. The whitish spots are normal. Many Hesperine genera include both golden-yellow and brown species, and in some cases one sex will be yellow, the other brown. The yellow *L. eufala* suggests that the change from one color to the other is biochemically "easy." If there is a mimetic or other advantage in golden-yellow pigmentation in California grassland skippers, the evolutionary opportunity for *L. eufala* to partake of it seems to be available.

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#### A POPULATION OF *LETHE APPALACHIA* (SATYRIDAE) FROM WEST CENTRAL FLORIDA

The southern limit in the geographical range of the eyed-brown satyr, *Lethe appalachia* Chermock, is reported by Kimball (1965, Lepidoptera of Florida, Fla. Dept. Agr.) to be northern Florida. Klots (1951, Field Guide to the Butterflies, Houghton Mifflin Co.) indicates that the species ranges southward in the Appalachian mountains into Georgia and to a few swampy locations in northern Florida. In July and August 1972, a sizeable population of this species was discovered in a swampy forest located two miles south of Zephyrhills, Pasco Co., Florida. The swamp is adjacent to Crystal Springs, the large spring contributing to the headwaters of the Hillsborough River in west central Florida. This locality is approximately 200 air miles south of those areas on the Florida-Georgia border where *appalachia* previously has been taken.

The initial collection was made on 28 July 1972, by members of my entomology class at the University of South Florida. Seven specimens were collected and many others observed flying about the swamp. Nearly all of them were in perfect condition indicating a recent emergence of adults. The dominant trees in this swamp are: water oak, *Quercus nigra* L.; bald cypress, *Toxodium distichum* (L.) Rich; sweet gum, *Liquidambar styraciflua* L.; blue beech, *Carpinus carolina* Walt.; red maple, *Acer rubrum* L.; water hickory, *Carya aquatica* (Michx.) Nutt.; and water ash, *Fraxinus caroliniana* Mill. Within the swamp, eyed browns were closely associated with specific areas having a ground cover of giant sedge, *Rhynchospora inundata* (Oakes) Fernald. In August, several larvae of *L. appalachia* were found feeding on this sedge and adults continued to exhibit a distinct preference for flying about and resting in the sedge patches.

The swamp was revisited on 7 October 1972, and several adult *L. appalachia* were still present and actively flying during the fall season. However, most of these individuals exhibited rather worn and tattered wings.

I have directed considerable effort toward collecting this species in other apparently suitable localities along the west-central coast of Florida without success. It appears that the colony at Crystal Springs is very local in distribution and perhaps represents a southern disjunct population which is more or less isolated from those in northern Florida.

Other species of butterflies collected within the Crystal Springs swamp in 1972 include the following: *Euptychia gemma* (Hübner), *E. hermes sosybia* (Fabricius), *Battus philenor* (Linnaeus), *B. polydamus lucayus* (Rothschild and Jordan), *Papilio polyxenes asterius* Stoll, *P. cresphontes* Cramer, *P. glaucus* Linnaeus, *Graphium marcellus* (Cramer), *Danaus gillippus berenice* (Cramer), *Heliconius charitonius tuckeri* Comstock and Brown, *Agraulis vanillae nigrior* Michener, *Phyciodes tharos* (Drury), *Polygonia interrogationis* (Fabricius), *Vanessa atalanta* (Linnaeus), *Limnitis archippus* (Cramer), *Asterocampa clyton* (Boisduval and Leconte), *A. celtis* (Boisduval and Leconte), *Saiyrium calanus* (Hübner), *Urbanus proteus* (Linnaeus), *Pyrgus oileus* (Linnaeus), *Erynnis zarucco* (Lucas), *Wallengrenia otho* (Abbot and Smith), and *Lerema accius* (Abbot and Smith).

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#### NOTES ON THE OCCURRENCE OF *HESPERIA PAHASKA MARTINI* (*HESPERIIDAE*) IN COLORADO

In August of 1967, one somewhat worn pair of specimens of a species of *Hesperia* were collected near Gateway, Mesa Co., Colorado. In May of 1968, 1969 and 1970 additional specimens of this same species were collected at Black Ridge Breaks, also in Mesa Co., Colorado. Upon first examination, these specimens were identified as *Hesperia viridis* (Edwards), but a closer examination of the short series, including genitalic dissections and comparison to long series of both *Hesperia viridis* and *Hesperia pahaska pahaska* Leussler from various sections of Colorado, established them as members of the *Hesperia pahaska* complex. Further comparison with descriptions of members of this complex in MacNeill (1964, Univ. Calif. Publ. Zool. 35: 136, 142-151, Pl. 1) established the specimens to be *Hesperia pahaska martini* MacNeill, the first reported specimens of this subspecies for Colorado. The most proximate published localities (MacNeill, op. cit.) are in Arizona (15 mi. WNW of Kayenta, Navajo Co.) and Utah (Beaver, Beaver Co.). Callaghan (1970, News Lepid. Soc. 3: 9) reported *martini* from the LaSal Mts., San Juan Co., Utah.

collected in early June of 1969. It may be noted that the former two listed by MacNeill are several hundred miles from both Colorado localities but that reported by Callaghan is within 50 air miles of the Gateway locality in Mesa Co., Colorado. MacNeill gives no indication of the possibility of *martini* occurring in Colorado by his distribution map for the *Hesperia pahaska* complex. It is now noted that the range of this subspecies has been extended eastward and that it has a much closer association with *H. pahaska pahaska* than previously known.

Although substantial series of this new discovery in Colorado are not available, it seems to depart from MacNeill's description of *martini* in two distinct characters. First, the macular band on the undersurface of the hindwings is composed of small rather than large spots, comparable with those of eastern Colorado *pahaska pahaska*. Second, in several specimens, the amount of fulvous suffusion in the borders of the fore and hindwings above is not as extensive and therefore, the insect is not as brightly marked as specimens from westward in its range. Intermediacy to *H. p. pahaska* is suggested by these two characters; however, the differences between these specimens and eastern slope *pahaska* are too substantial to consider them as intermediates and they should be referred to as *martini*. Colorado *martini* are comparable in size to that given by MacNeill with a FW range of 15–16 mm for the males and 16–18 mm for the females.

MacNeill suggests that this subspecies is double brooded, flying in the spring and again in September. Colorado specimens have been recorded from both of these times (May and August), thus confirming his suspicion. The larval food-plant is unknown but may be *Bouteloua gracilis* (H.B.K.) Lag.; Steud., the host for *pahaska pahaska* in Douglas Co., Colorado (J. Scott, in litt.).

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## RECENT SMITHSONIAN LEPIDOPTERA ACCESSIONS

### The Wilbur S. McAlpine Collection

Through the kindness and generosity of Mr. Wilbur S. McAlpine, Union Lake, Michigan, the bulk of his collection of Lepidoptera has come to the Smithsonian Institution.

This collection consists of over 12,000 specimens and is rich in material from the state of Michigan. In addition there is a series of Alaska butterflies collected by him in 1906 and again in 1911 and 1912 when he was Assistant Surveyor in a survey of coal claims at Homer, Alaska. Mr. McAlpine also was interested in the saturniid *Hyalophora columbia* and its hybrid with *H. cecropia* in Michigan and acquired a long series of these moths.

The most important part of his collection, however, consists of the genus *Calephelis* which was the subject of his, "A Revision of the Butterfly Genus *Calephelis* (Riodinidae)" (J. Res. Lepid. 10(1): 1–125, 1971). All described species of *Calephelis* are represented with the following types of new species and subspecies coming to the Smithsonian: *Calephelis sixola*, *C. perditalis donahuei*, *C. muticum*, *C. rawsoni*, *C. freemani*, *C. arizonensis*, *C. sinalcoensis nuevoleon*, *C. dreisbacki*, *C. stallingsi*, *C. huasteca*, *C. montezuma*, *C. acapulcoensis*, *C. azteca*, *C. yucatanana*, *C. maya*, *C. wellingi*, *C. wellingi baleuensis*, *C. clenchi* and *C. schausi*. Paratypes of the above and those of other species are included in the collection.

Other museums received holotypes and paratypes of some of McAlpine's new species and subspecies. The museums and the holotypes they received are: American Museum of Natural History: *Calephelis laverna trinidadensis*, *C. mexicana*, *C.*

*sacapulas*, *C. browni* and *C. tapuyo*. The British Museum (Natural History) received *Calephelis guatemala*, *C. braziliensis* and *C. burgeri*. The following were sent to the Carnegie Museum: *Calephelis nemesis bajaensis*, *C. costaricicola* (neotype), *C. sinaloensis*, *C. matheri*, *C. inca* and *C. aymaran*. *Calephelis nemesis dammersi* and *C. n. californica* are in the Los Angeles County Museum.

#### The E. J. Newcomer Collection

Mr. E. J. Newcomer, formerly of Yakima, Washington, concentrated his collecting on Lepidoptera of that state and divided his collection between Washington State University and the Smithsonian Institution, the latter receiving nearly 3,000 specimens. This block of material, from a restricted geographical area, forms a very representative collection of that fauna, and is particularly strong in the genus *Speyeria*.

#### The F. T. Vallins Collection

This excellent assemblage of material consists of more than 22,000 blues and coppers of the family Lycaenidae. All of the specimens are from the Palaearctic Region, and although there are no holotypes, there are long series from throughout the ranges of the species. These demonstrate all known forms of intraspecific variation that occur in the various localities. This is an extremely valuable collection for the study of variation and comparison of parallel development in American species.

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## NOTES AND NEWS

### PROPOSED AMENDMENTS TO THE CONSTITUTION OF THE LEPIDOPTERISTS' SOCIETY

The following changes in the Constitution of the Society have been proposed in order to:

1. add the immediate Past President to the Executive Council; and
2. change the inauguration date of the President, Vice-Presidents, and the Members-at-Large of the Executive Council from 1 January to the date of the annual meeting.

Notice is hereby given, in accordance with Article XII, Section 1, that these proposed amendments to the Constitution will be sent to the members with the ballots in November, 1973. Each section containing a proposed change is reproduced below in full, with new language in CAPITAL LETTERS; there are no proposed deletions.

Article IV, Section 2: The business and affairs of the Society, not otherwise provided for, shall be controlled by an Executive Council, consisting of the President, President-elect, THE MOST RECENT AVAILABLE PAST PRESIDENT, three Vice-Presidents, the Secretary, the Secretary-elect, the Treasurer, the Treasurer-elect, and nine other members of the Society. Action on all amendments to the By-Laws and all appointments and elections by the Executive Council shall be obtained by a canvass by the Secretary of all members of the Council.

Article V, Section 2: Election of Officers. All officers shall be elected by ballot. The President and all Vice-Presidents shall be elected for the term of one year, and shall be eligible to succeed themselves once. The Secretary and Treasurer shall be elected for the term of three years and shall be eligible to succeed themselves twice. The nine other elective members of the Executive Council shall be elected for the term of three years; three of them shall be replaced each year; these members shall not be eligible to succeed themselves. The President, the Secretary and the Treasurer shall be elected a year prior to the time they take office. For each office, the nominee receiving the highest number of ballots shall be elected. THE PRESIDENT, VICE-PRESIDENTS, AND NEWLY-ELECTED MEMBERS-AT-LARGE OF THE EXECUTIVE COUNCIL SHALL TAKE OFFICE AT THE BUSINESS MEETING OF THE ANNUAL MEETING FOLLOWING THEIR ELECTION; IN THE EVENT THAT NO ANNUAL MEETING IS HELD IN A GIVEN YEAR, THESE OFFICERS SHALL ASSUME OFFICE ON THE ANNIVERSARY OF THE LAST ANNUAL MEETING. ALL OTHER officers shall take office at the beginning of the calendar year for which they are elected.







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——— 1961a. Some contributions to population genetics resulting from the study of the Lepidoptera. Adv. Genet. 10: 165-216.

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# JOURNAL

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### *Memoirs of the Lepidopterists' Society*, No. 1 (Feb. 1964) A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA

by CYRIL F. DOS PASSOS

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# JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

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## DESCRIPTIONS OF NEW NEOTROPICAL HESPERIIDAE

S. S. NICOLAY

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Throughout the past 20 years, I have by collecting, trade and limited purchase, acquired a number of specimens of neotropical HesperIIDae which I believe are unnamed. A new subspecies of the Pyrrhopyginae was described previously (Nicolay & Small, 1969); eight species of the Pyrginae and HesperIIDae are herein described as new.

The descriptions utilize the English system of numbered veins and interspace identification found in Evans' works. Wing measurements are from base to apex. Unless of specific importance, generic characters are omitted from the descriptions of new species. Lengthy descriptions of the male genitalia are omitted, for each is shown in lateral view with the left valva removed, the aedeagus in place and the inner surface of the right valva figured. Notable differences from other species in the genus are discussed where appropriate and helpful. All line drawings were made by the author.

### ***Ouleus dilla baru* Nicolay, new subspecies**

Figs. 1, 2, 9, 9a

**Male:** Length of forewing, 15 mm. *Upperside:* both wings very dark brown, with faint, vague post discal band on forewing; a post basal and post discal band on the hindwing. *Underside:* dark brown; faint bands of upperside repeated on both wings. **Female:** Unknown.

**Holotype male,** Potrerillos, 1100 m., Chiriqui Province, Republic of Panama, 14 February 1970, S. S. Nicolay, collector. Holotype will be deposited in the American Museum of Natural History, New York, New York.

*O. dilla* was recently named by Evans (1953) from two specimens collected in Ecuador in 1896. The subspecies *baru* differs from the nominate form in having a completely dark brown hindwing beneath; *dilla* is white on the dorsal half of this wing. *O. d. baru* looks almost exactly like *O. fridericus salvina* and some dark specimens of *O. f.*



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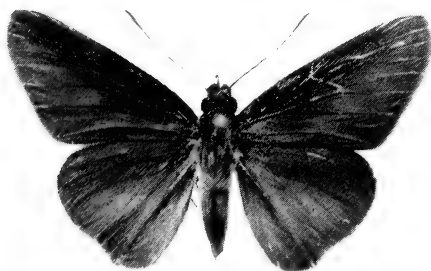
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Figs. 1-8. New Neotropical Hesperidae (Pyrginae and Hesperinae): (1, 2) *Ouleus dilla baru* Nicolay, upper and underside, holotype male, Potrerillos, Chiriqui Province, Panama, 1100 m., 14 February 1970; (3, 4) *Tosta sapasoa* Nicolay, upper and underside, holotype male, Sapasoa, Rio Huallaga, 500 m., San Martin,

*fridericus* and the very dark, unmarked *O. calavius*. The male genitalia of all are quite distinct, yet it is only with the most careful scrutiny that adults may be separated. Field collecting provides additional challenges, for many of the species of *Ouleus* look exactly like species of the genus *Staphylus* that occupy the same habitats, and fly in much the same manner.

### ***Tosta sapasoa* Nicolay, new species**

Figs. 3, 4, 10, 10a

**Male:** Length of forewing, 20 mm. *Upperside:* forewing brown, shaded and vaguely formed into areas of different intensity; basal two-thirds dark chocolate brown, outer third a paler brown; with a pronounced white-centered costal fold. Hindwing lighter brown, base darkened by heavy concentration of dark brown hairs; vague, narrow, brown discal and central bands, fading into ground color at tornus. All wings with a very faint purple cast; fringes brown. *Underside:* forewing base dark brown from costal margin to interspace 1b, the color formed by a heavy concentration of dense, short hairs; remainder of wing paler brown; fringes brown. Hindwing fulvous-brown, base darker; irregular discal and central bands of upper surface repeated, appearing more obvious due to lighter ground color; basal half of interspace 1c and adjoining cell area densely covered by long, grey hairs; interspace 1 and 1b heavily scaled in a mixture of light brown and grey scales, paler along inner margin and tornus; a light submarginal line of grey scaling continued from tornus along outer margin through interspace 3; fringes brown. *Palpi* below with a mixture of grey and brown hairs; above *head* and palpi black, *thorax* and *abdomen* dark brown; below abdomen light grey, with a single ventral black stripe. *Antennae* uniformly shining black above and below; nudum 21. **Female:** Unknown.

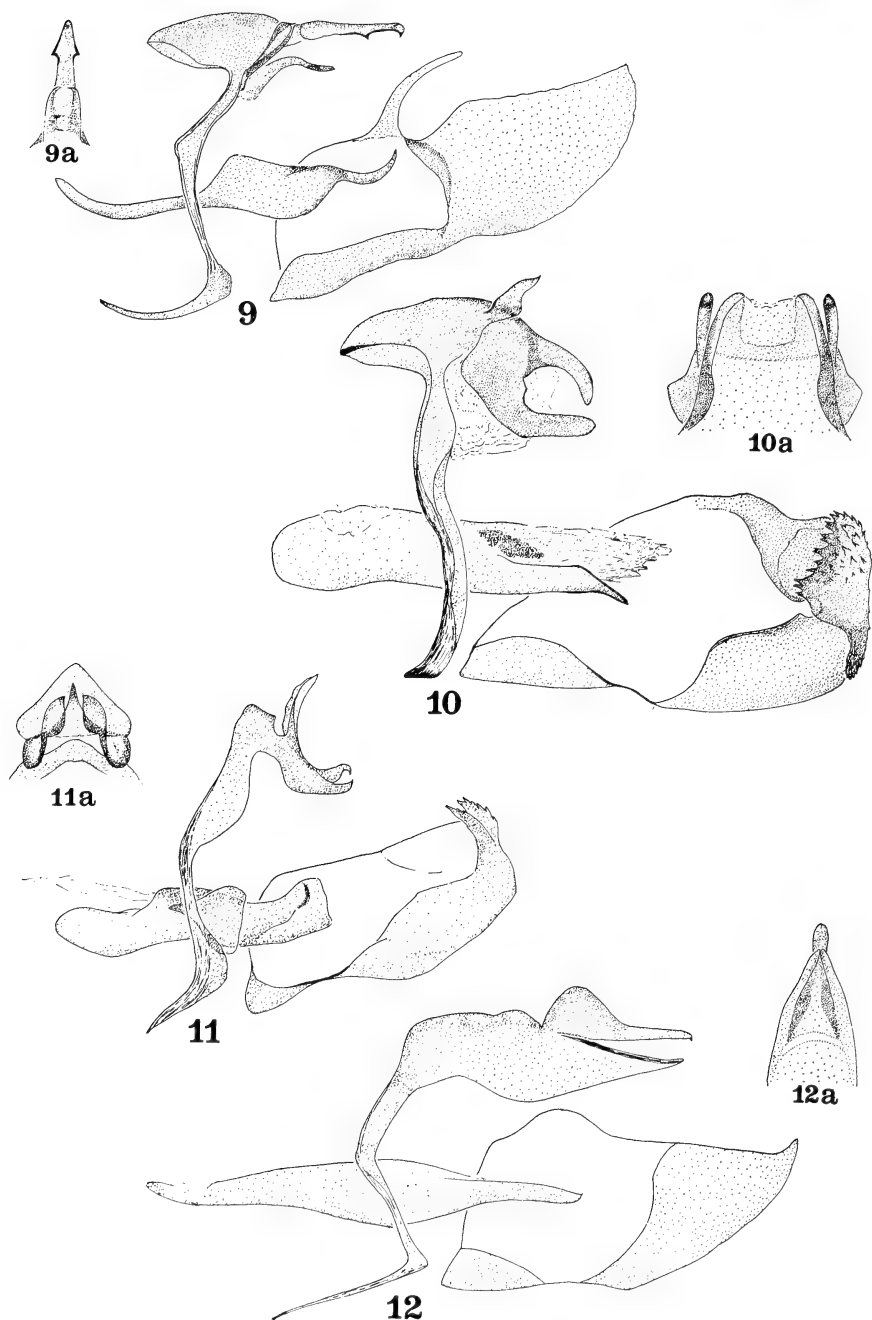
**Holotype male**, Sapasoa, 500 m., Rio Huallaga, San Martin, Peru, May 1954, Felix Wytkowski, collector. The holotype will be deposited in the American Museum of Natural History, New York, New York.

Evans (1953) erected the genus *Tosta* for a group of species allied to the genera *Anastrus* and *Achlyodes*, yet with marked differences from both. Certainly, the male genitalia of *T. sapasoa* bear a superficial resemblance to some *Achlyodes* and *Anastrus* species. Unlike the latter, *sapasoa* has a well developed costal fold in the male; it does not have a hair tuft on the hind tibia, nor the associated thoracic pouch. In wing pattern *sapasoa* resembles some species of *Anastrus*, yet the wide, heavy thorax, short, stout abdomen and very short forewing cell, place this species in the genus *Tosta*.

Based on the very brief description of Evans' *T. taurus* (1953), *sapasoa* closely resembles this species but is somewhat larger and is obviously separated by the genitalic differences. The male genitalia in *sapasoa*

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Peru, May 1954; (5, 6) *Damas immacula* Nicolay, upper and underside, holotype male, Colon (Sta. Rita) 300 m., Panama, 4 January 1969; (7, 8) *Damas immacula* Nicolay, upper and underside, allotype female, same locality as male, 1 January 1969.





form a very densely chitinous organ, replete with an extraordinarily wide, "horned" uncus and heavily spined cuillar. Both species are currently known only from single male types.

### ***Virga paraiba* Nicolay, new species**

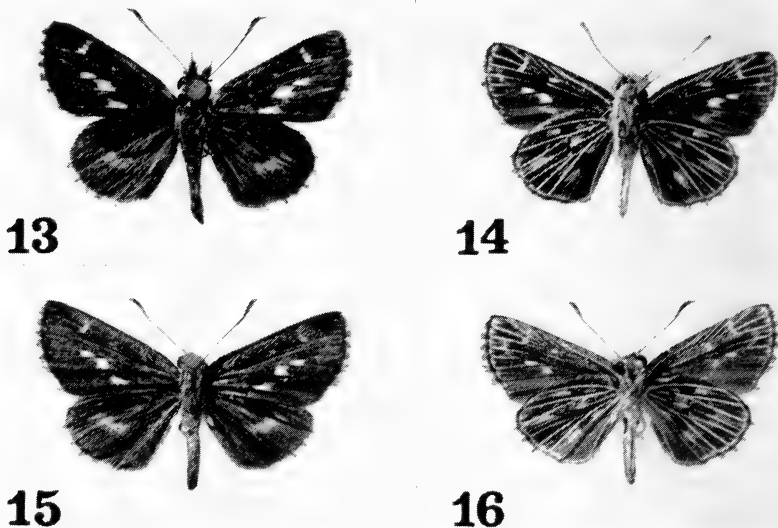
Figs. 12, 12a, 13, 14, 15, 16, 29

**Male:** Length of forewing, 9 mm. *Upperside:* forewing dark brown; a discal yellow spot in each of spaces 1b, 2 and 3, the largest in space 2; a tiny yellow upper cell spot, a straight line of three small yellow apical spots in spaces 6-8; sparse yellow scaling over the basal half of costal margin, the base of spaces 1a and 1b. Two small, dark brands over and under the origin of vein 2 (Fig. 29) their outer margins coincident with the inner edge of spot in space 2. Fringes sordid yellow, darkened at each vein end producing a faint checkered pattern. Hindwing dark brown; a discal row of fused yellow elongated spots in spaces 2-5; a few long yellow hairs over base of each wing; fringes light yellow with darkened vein ends producing a checkered pattern. *Underside:* forewing black; vein 12 and veins at apex yellow-scaled; also the medium veinlet from base to cell-end; a scattering of light scales across the discal area of spaces 1a and 1b with discal yellow spots in spaces 2 and 3; two pale violet spots near termen in spaces 4 and 5; a straight row of 3 apical spots; cell spot yellow. A yellow-scaled sub-terminal line from vein 1 to apex; a narrow post-terminal black line adjoins the wider dark brown base of grey fringes, darkened at each vein end. Hindwing dark brown, almost obscured by large areas of light violet spots and yellow-scaled veins; at the base of each wing, an arc of light violet conjoined spots from space 1b through cell and space 7; a broad irregular light violet discal band from space 1b through 7, most obvious in spaces 1c, 4, 5, and 7. All veins yellow and a yellow sub-terminal line; a heavy post-terminal dark line formed by the dark bases of yellow fringes, themselves darkened at each vein end. *Head, palpi and thorax* with mixed yellow and black scales; *abdomen* dark brown dorsally, yellow striped at the side, cream colored below with 2 dark ventro-lateral stripes. *Antennae* yellow below, lightly scaled with black at each joint, the color pattern reversed on the upper side. **Female:** Length of forewing, 8 mm. All wing maculation above and below, and body coloring repeated as in the male.

**Holotype male,** Joao Pessoa, Paraiba, Brazil, 31 March 1954, Jorg Kesselring, collector. **Allotype female,** same locality and collector, 8 February 1953. **Paratypes:** 15 male and 12 female paratypes, same locality and collector with dates recorded in the months of December, January, February, March, April and May in the years 1953 and 1954. The holotype will be deposited in the American Museum of Natural History, New York, New York. Paratypes will be deposited as follows: U.S. National Museum, Washington, D.C.; Carnegie Museum, Pittsburgh, Pennsylvania; Allyn Museum of Entomology, Sarasota, Florida; British Museum of Natural History, London, England and with Olaf H. H. Mielke, Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Paraná, Brazil.

←

Figs. 9-12. Male genitalia of new Neotropical Hesperiidæ (Pyrginae and Hesperinae): (9, 9a) *Ouleus dilla baru* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (9a); (10, 10a) *Tosta sapasoa* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (10a); (11, 11a) *Pamba boyaca* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (11a); (12, 12a) *Virga paraiba* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (12a).



Figs. 13–16. *Virga paraiba* Nicolay: (13, 14) holotype male, upper and under-side, Joao Pessoa, Paraiba, Brazil, 30 May 1953; (15, 16) allotype female, upper and underside, same locality as male, 8 February 1953. (Approximately 2× life size)

Evans (1955) writes that the species *virginus* Möschler is variable and could possibly be divided into subspecies with more material. Wing markings on both surfaces of *paraiba* are similar in many respects to those of Möschler's species, but the male genitalia are very different. In *paraiba* the uncus and gnathos are of equal length, the uncus with a distinct high crown; the gnathos of *virginus* is much shorter (almost non-existent) than the uncus and the uncus has no high crown. The valvae of *paraiba* are tapered evenly to a single curved point throughout their length; those of *virginus* are broad and sharply compressed to a point only at the very end.

Evans (1955) gives as a generic character, "♂ upf with a small, black, rounded brand over the origin of vein 2." In *V. paraiba*, without bleaching and removal of all but the brand scales, this indeed is what appears under the microscope; the actual brand-scales (Fig. 29) are covered rather effectively by a layer of other specialized, larger, black scales. Hayward (1951) figures this brand as one of three examples included in the genus *Callimormus* Scudder where he placed the *Virga* species *austrinus*. His key to the *Callimormus* species contains a brand (estigma) description for *austrinus* which is the same as that figured for *paraiba*. Critical examination of other *Virga* species may well determine this brand form to be the correct generic character.

The upper cell spot on the forewing appears to be a variable feature and is present in 9 of 16 males and in 8 of 13 females examined.

All specimens in the type series were taken by Mr. and Mrs. Jorge Kesselring at the type locality near their home. I have seen no specimens of *paraiba* from other localities.

### ***Pamba boyaca* Nicolay, new species**

Figs. 11, 11a, 17, 18, 31

**Male:** Length of forewing, 14 mm. *Upperside:* unmarked dark chocolate brown with sparse green hairs and scales on the collar and thorax. Forewing with a narrow, almost invisible tri-partite stigma from base of vein 3 along cubitus nearly to base of vein 2, thence directly in two short segments to middle of vein 1 (Fig. 31). *Underside:* forewing unmarked dark brown with heavier black scaling at base; hindwing dark chocolate brown with faint small cream colored postmedian spots in spaces 3 and 6; mixed green and brown hairs clothing thorax and base of legs; palpi thickly covered with intermixed grey and brown scales; antennae black, sparse yellow scaling under club; nudum 11. **Female:** Unknown.

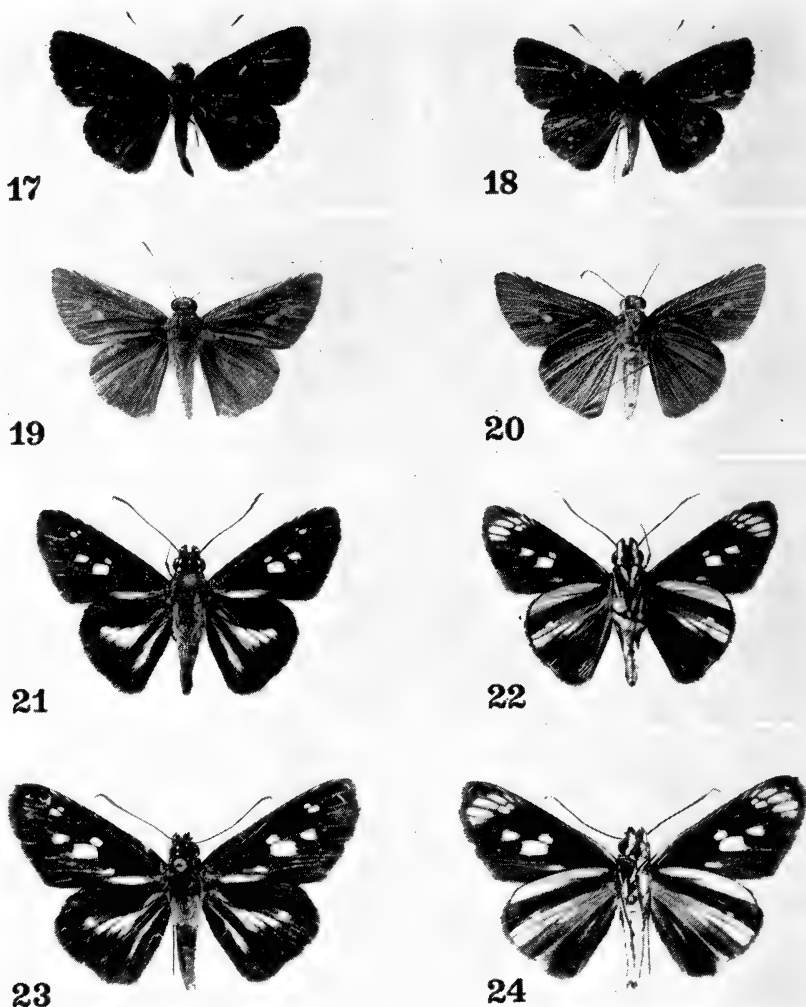
**Holotype male,** Arcabuco, 2200 m., Department of Boyaca, Colombia, 31 January 1971, S. S. Nicolay, collector. **Paratype:** One male, same data as the holotype. The holotype will be placed in the American Museum of Natural History, New York, New York. The single male paratype remains in the author's collection.

The genus *Pamba* was erected by Evans (1955) to accommodate a single unnamed species from Ecuador. The generic characters that establish this grouping are the shape of the long, narrow tri-partite stigma and the relatively long antenna with an obtuse apiculus. *Boyaca* differs from the sole previously known species *pamba* by its general lack of maculation on both wing surfaces; *pamba* has a narrow sub-tornal yellow area on the upperside hindwing, small silvery apical spots on the forewing underside and a pale yellow discal band on the hindwing underside. The valvae of the male genitalia are similar, but the uncus of *boyaca* is one of the most unusual forms I have encountered in any skipper. A dorsal plate or shield rises vertically from the horizontal plane of the uncus and dominates the entire lateral aspect of the genitalia. The chitinous sleeve or ring through which the aedeagus is articulated is neither mentioned nor shown by Evans in his illustration or description of *pamba*; it is however, a very obvious part of the male genitalia of *boyaca* (Fig. 11).

### ***Papias trimacula* Nicolay, new species**

Figs. 19, 20, 25, 25a

**Male:** Length of forewing, 15 mm. *Upperside:* both wings pale brown, the forewing with three small pale yellow discal spots in interspaces 1b, 2 and 3, the largest in interspace 2. *Underside:* both wings brown with pale fulvous oversealing along costal area of forewing and on all of hindwing; yellow spots in interspaces 2 and 3 on forewing; base and disc dark brown. *Palpi* missing; pale yellow scaling



Figs. 17-24. New species of Neotropical Hesperiidæ (Hesperiinae): (17, 18) *Pamba boyaca* Nicolay, upper and underside, holotype male, Arcabuco, 2200 m., Dept. of Boyaca, Colombia, 31 January 1971. (19, 20) *Papias trimacula* Nicolay, upper and underside, holotype male, Ft. Clayton, Canal Zone, 21 September 1963; (21, 22) *Vettius chagres* Nicolay, upper and underside, holotype male, Colon (Santa Rita), 300 m., Panama, 29 January 1972; (23, 24) *Vettius chagres* Nicolay, upper and underside, allotype female, Colon, Piña, Panama, 200 m., 24 November 1972.

around eyes and collar; *head*, *thorax* and *abdomen* brown above, paler below with abdomen pale yellow, almost white. *Antennae* with a faint checkered pattern above, more pronounced below, yellow under club, nudum red-brown, 3/10. **Female:** Unknown.

**Holotype male**, Ft. Clayton, Panama Canal Zone, 21 September 1963, G. B. Small, collector. The holotype will be deposited in the American Museum of Natural History, New York, New York.

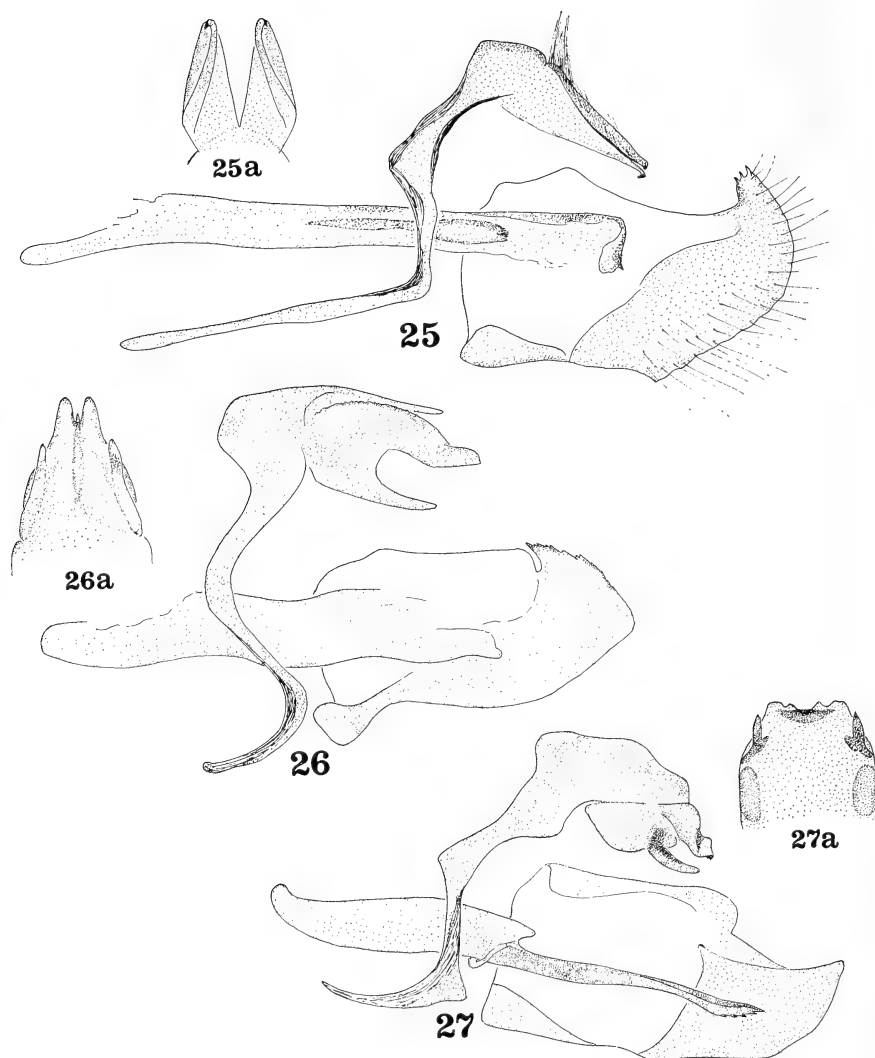
*Trimacula* is undoubtedly the lightest colored species in the genus, rivaling Evans' smaller species *quigua* from Venezuela. Although some others of the genus are marked with spots on the underside, *trimacula* is the only species with obvious, albeit pale and inconspicuous, markings on the upper surface. In this respect as well as the single added segment of the nudum on the apiculus (10 instead of 9), this species does not fit the exact generic criteria set forth by Evans (1955). However, the male genitalia with a quadrid fimbria, very long saccus and equally long aedeagus places *trimacula* in the genus *Papias* as defined by Godman (1900).

### **Vettius chagres** Nicolay, new species

Figs. 21, 22, 23, 24, 27, 27a, 32

**Male:** Length of forewing, 17 mm. *Upperside:* forewing black, white hyaline spots in spaces 2, 3 lower cell and small sub-apical spots in spaces 6 and 7, the larger in space 6; a dense layer of blue-white hairs from the base along vein 1 in space 1a to midwing; short black bands above and below the origin of vein 2. Sides of collar and tegulae dark orange. Hindwing black with a prominent blue-white streak from base the length of space 1b, completely separate from the triangular white discal band running from spaces 2-5, the white spots hyaline in spaces 3-5, widest in space 2 consisting of long white hairs, all spots divided by dark veins. Fringes narrowly white at tornus. *Underside:* forewing dull black; a wide, short yellow pre-apical band cut by dark veins in interspaces 4 thru 8; hyaline white spots as above, with added small semi-hyaline white spot in 1b. Hindwing, space 1a dull orange; space 1b and distal half of 1c black; basal half of spaces 1c through 4 and cell orange; a tapered discal band of white semi-opaque spots in spaces 3-5, spaces 3 and 4 yellow from end of spots to termen; spaces 5 and 6 black from base to termen; spaces 7 and 8 clear yellow except bases and costal margin narrowly black; fringes paler at tornus. Sides of *thorax* at base of wings, orange. **Female:** Length of forewing, 19 mm. *Upperside:* same as in male, but forewing longer, narrower with a white spot mid space 1b; hindwing wider. *Underside:* same as in male.

**Holotype male**, Colon (Santa Rita), Republic of Panama, 300 m., 29 January 1972, S. S. Nicolay, collector. **Allotype female**, Panama, Colon, Piña 200 m., 24 November 1972, H. L. King, collector. **Paratypes:** 1 male, same locality as holotype, 4 February 1970; 1 male, Gatun, Canal Zone, 10 January 1972, S. S. Nicolay, collector; 3 males, same locality as holotype, 5 January 1969, 7 February 1969; 4 males, Gatun, Canal Zone, 9 December 1969; 2 females, same locality, 26 June 1970, 2 December 1972, G. B. Small, collector; 1 male, same locality as holotype, 19 February 1969; 16 males and 3 females, Piña, Colon, Republic of Panama, 200 m., H. L. King, collector. The holotype will be placed in the American Museum of Natural History, New York, New York. Paratypes will be deposited as follows: U.S. National Museum, Washington, D.C.; Carnegie Museum, Pittsburgh, Pennsylvania; Allyn Museum of



Figs. 25-27. Male genitalia of new Neotropical HesperIIDae (HesperIIDae): (25, 25a) *Papias trimacula* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (25a); (26, 26a) *Damas immacula* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (26a); (27, 27a) *Vettius chagres* Nicolay, lateral view of genitalia and ventral view of gnathos and uncus (27a).

Entomology, Sarasota, Florida; and the British Museum of Natural History, London, England. The allotype and remaining paratypes will remain in the collections of the author and Mr. G. B. Small.

The male genitalia of *chagres* are almost identical to those of *V. phyllus* Cramer. Evans (1955) lists four subspecies for *phyllus* and I originally considered *chagres* to be a fifth taxon. But, with additional collecting and further careful study it became rather obvious that *chagres* and *phyllus* were two distinct, separate species. Both species have been collected in the forest-clothed hills and mountains on the Atlantic coast side of the Isthmus in the Gatun/Piña and Colon area. I have found no intergrades in either sex between the two species in a careful study of rather substantial series of both species, taken within a few miles of one another and, in some instances, in the same locality.

There are a number of consistent, distinct differences between the two species: on the upperside, *chagres* lacks the orange scaling on the forewing costa, the spot in space 1b on the forewing is missing or tiny, and the white discal band on the hindwing is triangular in shape, with a definite, long concave dorsal edge; *phyllus* has the basal half of the costa on the forewing, dull orange, the white spot in space 1b of the forewing is always present, and the white discal band on the hindwing is rectangular (almost ovoid), and about the same width throughout. The underside of the hindwing in *chagres* is strikingly different from typical *phyllus* or its subspecies; the large orange basal area and the appearance of the white discal spots of the upperside are the most notable differences. The obvious white streak mid space 1b in *phyllus* is missing in the *chagres* male, and marked by a few white scales in the female.

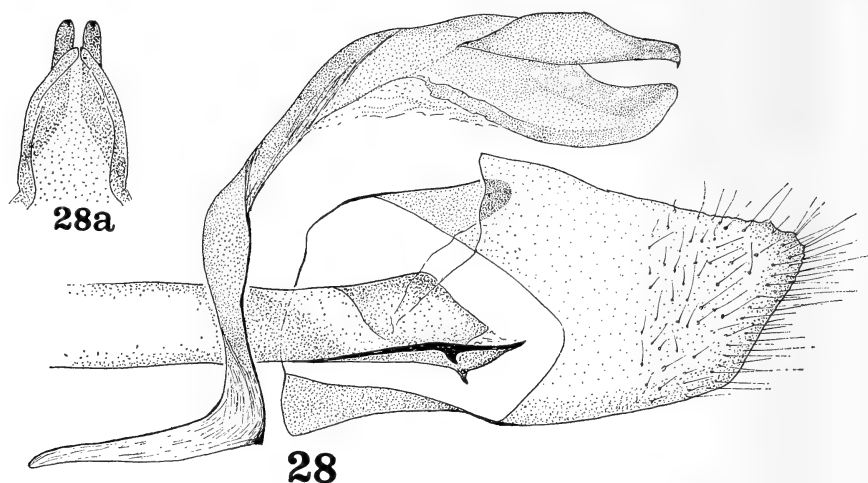
The known range of *chagres* thus far appears to be the forested hills on the Atlantic side of the Isthmus in the Canal Zone, and the adjoining areas of the Republic of Panama.

### **Damas immacula Nicolay, new species**

Figs. 5, 6, 7, 8, 26, 26a, 30

**Male:** Length of forewing, 23 mm. *Upperside:* all wings unmarked, dark, chocolate brown; forewing with a broad, grey bipartite stigma divided by vein 2. Hindwing fringes yellow from inner margin through tornus to vein 6. *Underside:* forewing unmarked dark brown; hindwing unmarked dark chocolate brown with a faint reddish tinge; fringes yellow-orange from inner margin through tornus to vein 6. **Female:** Length of forewing, 24 mm. *Upperside:* all wings unmarked dark chocolate brown. *Underside:* forewing brown, with a vague pale sub-apical band from the costal margin to mid-termen dividing wing into a vaguely darker apical area and lighter proximal area; space 1b paler with a wash of yellow overscaling; hindwing dark brown from the costal margin through cell and portion of space 3, ventral half clear yellow; a thin dark brown marginal line to vein 2; yellow fringes from inner margin through tornus to vein 6.

**Holotype male,** Colon (Santa Rita), 300 m., Republic of Panama, 4 January

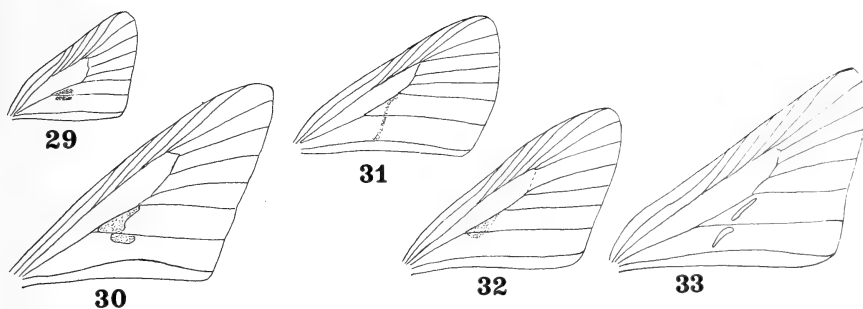


Figs. 28–28a. Male genitalia of *Thespius inez* Nicolay, lateral view and ventral view of gnathos and uncus (28a).

1969, collector, S. S. Nicolay. **Allotype female**, same locality and collector, 1 January 1969. **Paratypes**: 2 males with the same data as the holotype; 2 males, same locality and collector, 1 January 1969; 1 female, same data as allotype; 1 female, same locality and collector, 5 January 1969; 2 females, same locality, 1 January 1969, 16 February 1969, collector, G. B. Small; 1 female, Farfan, Canal Zone, 2 February 1968, collector, S. S. Nicolay. The holotype will be deposited in the American Museum of Natural History, New York, New York. Paratypes will be deposited in the U.S. National Museum, Washington, D.C., and in the Allyn Museum of Entomology, Sarasota, Florida. The allotype and remaining paratypes will remain in the author's collection and that of Mr. G. B. Small.

Evans (1955) in his discussion of *Damas clavus* Herrich-Schaffer, the only species in this genus, refers to the rather wide variability in wing markings to be found in both sexes. It has become apparent to me, after an exhaustive search of the literature, and study of extensive material in the American Museum and Smithsonian collections, that this variability does not include the unmarked, spotless species herein described as *immacula*. In spite of the very close similarity in the male genitalia of the two, it would be difficult to place *immacula* in the category of a subspecies; I have taken both sexes of "typical" *clavus* in the same area and at the same time with *immacula*. This fact would also tend to negate the possibility that it might be only a seasonal form. Although Evans mentions 3 males and 1 female in the long series of *clavus* in the British Museum collection as being without spots on the forewings, none is from Panama. Of the two sexes, females of *immacula* offer the most compelling and obvious characters of a specific value. Yet, the yellow





Figs. 29–33. Forewing male stigmatal patterns: (29) *Virga paraiba* Nicolay; (30) *Damas immacula* Nicolay; (31) *Pamba boyaca* Nicolay; (32) *Vettius chagres* Nicolay; (33) *Thespius inez* Nicolay.

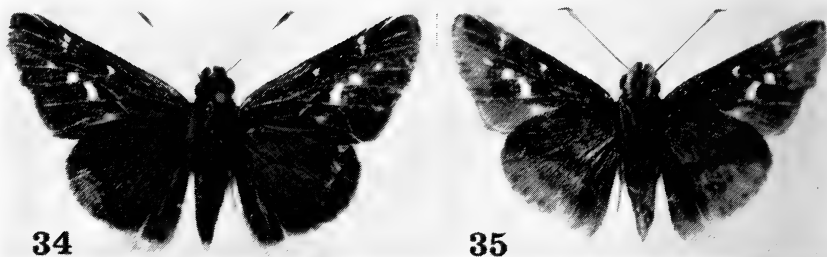
hindwing beneath is not mentioned in previous literature, nor does Evans discuss this feature in combination with his single spotless female. The wide yellow ventral half of the underside of the hindwing is a color pattern also found in other large skipper species found in this same region—*Tromba xanthura* Godman, *Astraptus anaphus annetta* Evans, and *Achlyodes busirus heros* Ehrmann.

*D. immacula* is found in the tropical forested hills on the Atlantic and Pacific sides of the Isthmus of Panama. Both sexes are particularly attracted to the large purple and white flower of a “morning glory” vine of the genus *Ipomaea* in the Family Convolvucidae that covered fallen timbers and areas laid waste by wood-cutters. Both sexes are very wary and powerful fliers. With extreme care, they could be netted while feeding on the flowers, but once missed, offered no second chance for capture.

### ***Thespius inez* Nicolay, new species**

Figs. 28, 28a, 33, 34, 35

**Male:** Length of forewing, 24 mm. *Upperside:* forewing dark brown, base of interspaces 1b and 1 thinly clothed with long blue hairs; a faint white spot mid interspace 1b, a narrow rectangular spot in space 2, a small square spot in space 3, a small triangular spot in space 4; 3 small sub-apical square spots in-line from spaces 6–8; a very small crescent-shaped upper cell spot; all spots white and hyaline. A narrow, pale, broken stigma from base of vein 3 to vein 1 (Fig. 32). Fringes at tornus yellow to vein 2. Hindwing dark brown, base clothed in long blue hairs, with a pale yellow tornus 2 mm at the widest point centered at vein 1, extending to vein 2 and opposite through tornus to inner margin; tornal fringes yellow. *Underside:* forewing red-brown along costa with lilacine scaling on outer margin from apex widening to include spot in space 4, terminating at a point just inside space 2; dark brown in disc, hyaline spots as on upperside; spot in space 1b enlarged by white scaling. Hindwing red-brown with a wide bar of heavy lilacine scaling from vein 6 through end of cell to mid-point of vein 1; abdominal fold dark brown, remainder of wing with intermixed lilacine scaling, at some points



Figs. 34 & 35. *Thespius inez* Nicolay, upper and underside, holotype male, Arcabuco, 2200 m., Dept. of Boyaca, Colombia, 31 January 1971.

quite heavy; tornus pale yellow, 4 mm wide from vein 2 to inner margin; fringes yellow from vein 5 through tornus. *Head*, *thorax* and *tegumen* dark red-brown, mixed with long blue hairs on the thorax. *Abdomen* dark brown, anterior clothed with long blue hairs, posterior tip yellow. *Palpi* with mixed brown and light grey hairs and scaling. Below, *thorax* and *legs* clothed with red-brown hairs, abdomen with orange-yellow hairs; *Antennae* brick-red at bend of apiculus, yellow on the club beneath. **Female:** Unknown.

**Holotype male**, Arcabuco, 2200 m., Department of Boyacá, Colombia, 31 January 1971, S. S. Nicolay, collector. The holotype will be placed in the American Museum of Natural History, New York, New York.

This is a large hesperiid by any standard, and the largest of this genus I have yet seen. The reduced hyaline markings of the forewings, complete lack of markings on the hindwings above, and the yellow tornal marking on both hindwing surfaces make *inez* something other than a typical species of the genus *Thespius*. Wing maculation and the male genitalia relate it closely to *T. pinda* Evans, known only from the type which I have not seen, and the subspecies *ovallei* Bell of *T. tihoneta* Weeks. The illustration of *tihoneta* Weeks (1905) bears little resemblance to *inez*. My vivid impression of *inez* is that, like many of the genus, it is very wary and an incredibly fast and powerful flyer. It is also, like its closest relatives, rather rare; each of the three is currently known only from a single male in each species.

It is a pleasure to name this interesting species after Inez Schmidt-Mumm, the wife of Dr. Ernesto W. Schmidt-Mumm of Bogota, Colombia.

#### ACKNOWLEDGMENTS

I want to thank Mr. Gordon B. Small of the Canal Zone and Dr. Ernesto W. Schmidt-Mumm, Bogota, Colombia for their help with extensive field work, and invaluable logistic support for my own collecting efforts; their enthusiasm and assistance make such a study as this both a possibility and a pleasure. I very much appreciate the help of

Mr. and Mrs. H. L. King who collected an extensive series of the new species of *Vettius* for this study. Additionally my thanks to Gordon Small and Gerald Straley for helpful suggestions on the manuscript and to Dr. C. Don MacNeill of the Oakland Museum for his critical review of the final draft. To Dr. Ronald W. Hodges of the Smithsonian Institution, my thanks for help in solving a rather interesting and puzzling problem of subspeciation. Wm. D. Field, U.S. National Museum and Dr. F. H. Rindge, American Museum of Natural History provided the assistance and cooperation that allowed me to examine the material in the collections in their care.

Most of the photographs were made with the help of WO G. G. Williams, SSgt. Richard E. Banzal and Pfc. Robert Egner of the U.S. Marine Corps. Their technical help, capable assistance, and enthusiastic support are deeply appreciated. Photographs of the female of the new *Vettius* species were made by the Smithsonian Institution.

Determination of plant specimens was made by Dr. Robert Dressler of the Smithsonian Institution in the Canal Zone.

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## THE LIFE CYCLE OF *DIRCENNA RELATA* (ITHOMIIDAE) IN COSTA RICA

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This paper summarizes a variety of observations on the life cycle and natural history of the neotropical butterfly, *Dircenna relata* Butler & Druce, as studied in Costa Rica. While such studies of Brazilian members of the tribe Dircennini have been conducted (Brown & D'Almeida, 1970), the Central American ithomiid fauna generally remains to be studied in this respect. The excellent systematic studies of Central American Ithomiidae (Fox, 1968) provide a good basis for comparative studies on the biology of these butterflies and forms the foundation for examination of phylogenetic trends with respect to foodplant exploitation, behavior patterns, and a wealth of other factors underlying population biology. This paper represents an effort to study the biology of Costa Rican Ithomiidae, and supplements other similar reports (Young, 1972, in press).

### METHODS

Field observations were carried out intermittently during June–September 1971 at Bajo la Hondura (San Jose Province), a montane tropical forest locality (800–1000 m. elev.) in central Costa Rica. Observations were confined to a small breeding population of *D. relata* located at the bottom of the steep ravine at Bajo la Hondura; this population was discovered in exposed second-growth brush bordering the Rio Claro in the ravine.

Field studies or observations consisted of: (1) description of the life cycle, including estimation of developmental time and studies of larval hostplant specificity, (2) analysis of oviposition behavior, and (3) notes on larval behavior. Developmental time and larval hostplant specificity were studied in the laboratory. For these purposes, larvae at low densities were confined in tightly sealed plastic bags containing cuttings of hostplants.

### RESULTS

#### Life Cycle and Developmental Time

The egg (Fig. 1,A) is barrel-shaped and truncated at the base. It bears several deep vertical ribs and many less distinct horizontal ribs. The egg (0.7 mm × 0.6 mm) is cream-colored when first laid but becomes deep yellow within a day. The vertical ribs remain cream-colored as the

egg changes color. The first instar larva is light green with three dorsal rows of yellow spots. The two outer rows appear continuous and the head is uniformly light green. The larva measures about 3.5 mm by the first molt. The second instar (Fig. 1,B) is remarkably similar to the first but the central row of yellow spots now becomes interrupted with a complex patchwork of yellow and black spots. It is difficult to describe the body color pattern in terms of segments because these have become strongly subdivided in the Dircennini. The spots in the central row become square-shaped while the two outer rows continue to remain less distinct. The second instar is about 8 mm long by the second molt.

The third instar (Fig. 1,C) is very similar to the previous one, although now the general body color becomes dark green. The yellow patchwork and mottling of previous instars is retained in this instar. By the third molt the larva is about 13 mm long. The fourth instar (Fig. 1,D) resembles the previous instar and measures about 19 mm long by the fourth molt. The fifth and final instar (Fig. 1,E) is lighter green (like the second instar) and the yellow and black patchwork has become more diffuse. This instar attains a size of about 24 mm in length by 5 mm in width before changing into a truly mobile prepupa.

The prepupa is uniformly translucent light green with the yellow markings barely visible. It is an extremely active form but seldom crawls off the hostplant for pupation. The pupa measures about 11 mm in length and 7 mm in width (dorsoventrally in the thoracic region) and its coloration is somewhat variable; on light backgrounds the pupa is light green with gold markings (Fig. 1,F) while on dark backgrounds the pupa is reddish-brown with gold markings (Fig. 1,G). The gold markings in both forms are confined to rings around abdominal segments, legs, thorax, and wing veins. The cremaster in both cases is pink. To the human observer the pupae of this butterfly are very dazzling and reflective and when several are found together in the field they give the appearance of large drops of water reflecting sunlight.

Adults of both sexes are similar in size, having a forewing radius of about 31 mm ( $N = 23$ ). There is very little sexual dimorphism in the delicate translucent orange ground coloration of the wings (Fig. 1,H). Descriptions of wing coloration are given by R. Haensch in Seitz (1924) and more recently in greater detail by Fox (1968).

Developmental time from egg to adult is summarized in Table 1. Despite a mean developmental time of 25 days, females take about a day longer to complete ontogeny. In a total of 50 emergences, the sex ratio did not deviate significantly from unity, there being 28 males and 22 females.

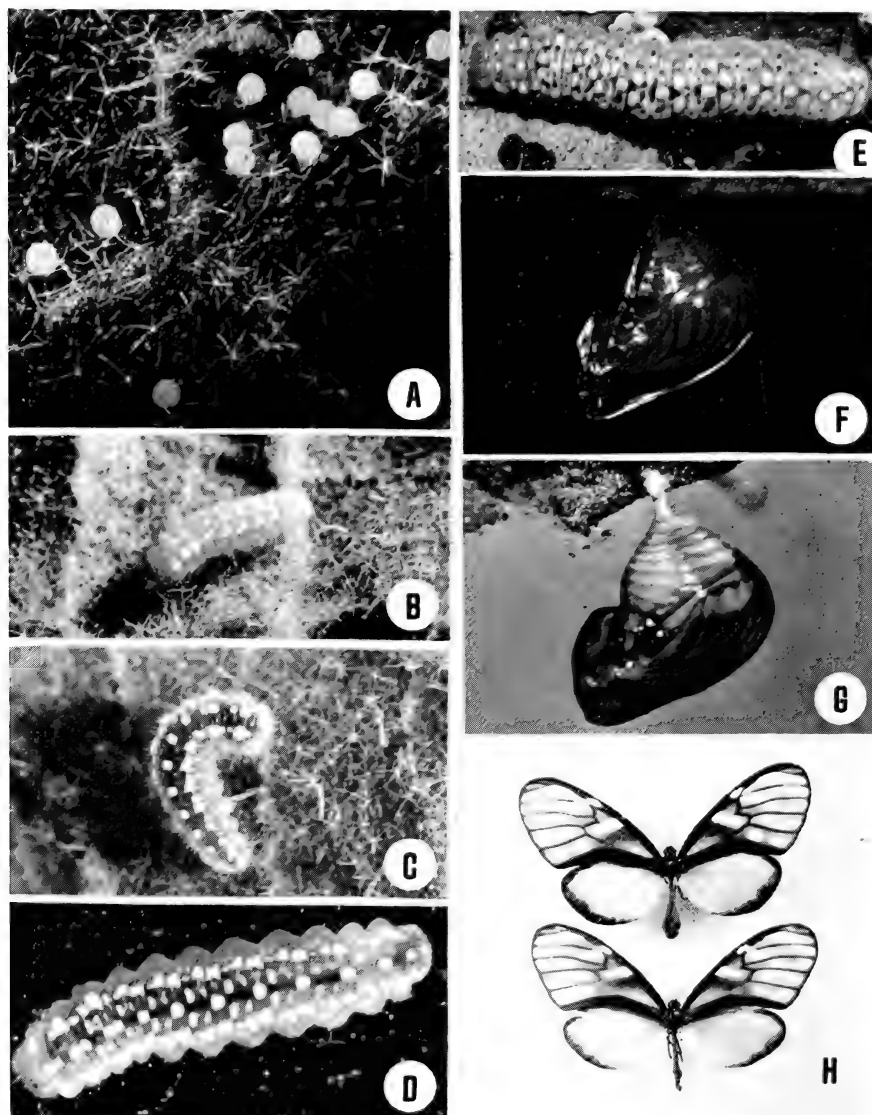


Fig. 1. Life cycle of *Dircenna relata* Butler & Druce: (A) eggs; (B-E) second, third, fourth, and fifth instars, respectively; (F-G) light and dark forms of pupa, respectively; and (H) adult female (above) and male (below).

TABLE 1. The developmental time<sup>a</sup> of *Dircenna relata* Butler & Druce (Ithomiinae) on its larval foodplant, *Solanum hispidum* (Solanaceae).

Statistics	Instars						Pupa
	Egg	1	2	3	4	5 <sup>b</sup>	
Mean (days)	5	2	2	2	3	5	6
± S.E.	0.3	0.1	0.4	0.2	0.2	0.8 <sup>d</sup>	0.8
No. individuals studied	42	37	37	37	34	34	34
Died	0	6 <sup>c</sup>	0	0	3	0	0

<sup>a</sup> Measured in the laboratory conditions (20–24°C).

<sup>b</sup> Includes an active prepupa which lasts about one day.

<sup>c</sup> This mortality apparently due to handling effects.

<sup>d</sup> Females longer in development, by about 1 day, occurring in the fifth instar.

### Larval Host Plant Specificity

At Bajo la Hondura the major larval hostplant is *Solanum hispidum* Pers. (Solanaceae) which grows along the edges of the Rio Claro (Fig. 2). This plant (see Standley, 1937 for description) is common in thickets of second-growth vegetation in central Costa Rica between 1300–2000 m elevation, and occurs as an armed shrub or small tree (1.5–3.0 m tall) (D.C. Wasshausen, pers. comm.). Geographically this species occurs northward to Mexico and perhaps southward into Panama. At the study site individual plants are highly scattered along the river edge (Fig. 2) and seldom occur in homogeneous patches.

Although this was the only hostplant I found for *D. relata* at Bajo la Hondura, caterpillars complete development successfully (with same developmental time) in the laboratory on several other species of *Solanum*. I tested the following species from various parts of Costa Rica: (1) *S. laurefolium* (from Vara Blanca, Heredia Province, 600 m elev.), and (2) *S. orchraceo-ferrugineum* (from San Miguel, Heredia Province, 100 m elev.). Both of these species appear very similar to *S. hispidum* both in life form and distribution of spines on leaves and stems. Neither one occurs at Bajo la Hondura, however.

### Larval Behavior

Larvae devour their empty egg shells and always remain on the ventral surface of the leaf. Feeding may begin virtually anywhere on a leaf (i.e. first instars do not necessarily feed at the edge of a leaf). Although several caterpillars may be found on a single leaf of *S. hispidum*, they are never gregarious. This is in sharp contrast to the larvae of *Mechanitis isthmia isthmia* Bates (Ithomiidae), in which both feeding and resting are highly gregarious. But nongregarious larval behavior also occurs in other species of Costa Rican ithomiids such as *Godlyris caesiopicta*



Fig. 2. Habitat and hostplant of *Dircenna relata* Butler & Druce at Bajo la Hondura, Costa Rica. Both adult *D. relata* and individuals of *Solanum hispidum* (large inset to the left), the major larval host plant, are distributed sparsely along the rocky edge of the Rio Claro (remainder of photo). The hostplant does not occur in the primary-growth forest lining the Rio Claro further back.

Niepett\* (Young, in prep.), *Napeogenes tolosa amara* Godman (Young, in prep.), *Hymenitis nero* (Hewitson) (Young, 1972), and *Pteronymia notilla* Butler & Druce (Young, in press).

Larvae appear to be cryptically colored when on the undersides of the very hairy leaves of *S. hispidum*, and younger instars are especially difficult to find in the field. All instars are generally diurnal feeders, resting at night near major veins of leaves. In the field, larvae of all instars are most frequently encountered on the lowest leaves of *S. hispidum*, and mixed age groups are frequently seen. Larvae have never been found on apical leaves.

Neither predation nor parasitism on larvae have been observed in the field. Of a total of 37 additional larvae (of all instars) collected in the field and reared in the laboratory, none gave rise to parasitic flies or wasps.

\* This is the old name for this subspecies, and it was brought to my attention by Keith S. Brown, Jr., who encountered it in *Lepidoptera Niepettiana* (Vol. 2); it was renamed by R. M. Fox as *G. z. sorites*.



### Oviposition Behavior

Oviposition sequences were witnessed on several occasions, first on 11 July 1971 at 1220 (CST). A female patrols around the hostplant, lights on the ventral surface of a large, older leaf near the ground, and walks around, depositing several eggs. Eggs are loosely clustered (Fig. 1,A) and many are only loosely attached to the leaf by entwining hairs (i.e. there is no actual adhesion of eggs to the leaf). Eggs are not clustered in an orderly fashion as seen in other species of ithomiids (e.g. *Mechanitis isthmia*) but rather are scattered haphazardly on the leaf. It is possible that some eggs may become jarred loose, perhaps resulting in substantial mortality. However, it is equally possible that eggs are held securely by the very dense leaf hairs (Fig. 1,A).

Eggs frequently are laid on leaves where eggs had been desposited previously. The same female will often return to the same leaf to lay additional eggs over several successive oviposition sequences. Eggs are not laid on the younger apical leaves of the hostplant. An individual female, on the average lays between 1 and 14 eggs during a single visit to a leaf. Females always "drum" a leaf with the forelegs before laying an egg. Oviposition at Bajo la Hondura probably occurs throughout the day, although it is most frequent between 1130 and 1430.

Undoubtedly ovipositing females are quite vagile owing to the highly dispersed distribution of *S. hispidum*. A female ovipositing on a given individual hostplant will fly away after several oviposition sequences (i.e. after about 10 minutes of interrupted patrolling) and may search for other individual plants on which to oviposit.

Courtship activity has never been observed in the immediate vicinity of hostplants. This behavior may occur in the understory of the primary growth forest that covers the sides of the ravine at Bajo la Hondura.

### DISCUSSION

Although the Ithomiidae are generally solanaceous-feeding butterflies in the caterpillar stage, rendering at least one species unpalatable to some predators (Brower & Brower, 1964), it is apparent that this group has experienced several lines of phylogenetic diversification into several tribes differing substantially in morphology of both adults and immatures (Fox, 1940, 1967, 1968; Brown & D'Almeida, 1970). One of these tribes is the Dircennini, which contains several genera including *Ceratinia*, *Dircenna*, and *Pteronymia* (see Brown & D'Almeida, 1970, p. 14-15). Since these and other genera within this tribe presumably share some portion of their evolutionary history, it is interesting to discuss the life cycle and natural history data for *D. relata* in terms of similar studies of

other genera in the tribe, and genera in other tribes. It is realized, however, that contemporary differences in the biological properties of different species and genera in any animal group must not only be molded by evolutionary history, but also by simultaneous ecological factors operating on breeding populations (Birch & Ehrlich, 1967). The following comparisons are limited to a few illustrative examples that emphasize both similarities and divergences in life cycle and natural history.

Young (in press) found that *Pteronymia notilla* at Cuesta Angel in Costa Rica has an egg-adult developmental time of about 30 days on *Cestrum megalophyllum* (Solanaceae), which is about five days longer than the developmental time of *D. relata* on *Solanum hispidum*, under similar conditions. Brown & D'Almeida (1970) report a developmental time of about 45 days for *Ceraticada canaria* on *Solanum caavurana* under presumably laboratory conditions in Rio de Janeiro. Young (1972) found the developmental time of *Hymenitis nero* (not in the Dircennini) on *Cestrum standleyi* (eggs from a Cuesta Angel population) to be about 30 days in the laboratory. Based on these very fragmentary records involving different foodplants, it is still not possible to assign generic or tribal differences in developmental time for these ithomiids. With respect to the duration of the egg stage, if we assume equal environmental conditions for the forementioned species, the genera *Dircenna*, *Pteronymia*, and *Hymenitis* (as represented by the species discussed) all have an incubation period of 4–5 days; but the incubation period of *Ceraticada* is 9–10 days (Brown & D'Almeida 1970). It is very likely that there exists a wealth of unpublished measurements of egg-adult developmental in many genera and species of ithomiids on various foodplants by workers in Central and South America; I would like to make a plea to bring all of these data together and look for a phylogenetic pattern of developmental time (within tribes), especially where similar foodplants are involved. If more information is obtained regarding leaf toughness and secondary compounds for different genera of Solanaceae, such data would also shed light on developmental time differences resulting from foodplant differences rather than evolutionary history among the ithomiids. Since incubation period may be only indirectly influenced by foodplant (in cases where the female's foodplant affects egg duration), it may be best to examine differences in duration of the egg stage among genera and tribes.

Rather pronounced differences in external morphology of immatures are also evident among different genera of ithomiids. For example, the egg of *D. relata* is very different in appearance from that of *Hymenitis nero*, *Pteronymia notilla*, and *Ceraticada canaria*. First, the egg of *D.*

*relata* is deep yellow, essentially spherical, and has a system of external horizontal and vertical ribs; the egg of *P. notilla* is white and more oblong in shape than the egg of *D. relata* (Young, in press). Furthermore, it lacks very definite horizontal ribs. While the egg of *H. nero* is also uniformly white, its shape approaches that of *D. relata* and it has a similar array of vertical ribs as seen in *P. notilla*. Although the egg of *C. canaria* is white, the shape and distribution of vertical and horizontal ribs (grooves) are similar to that of *D. relata* (as determined from the egg description of *C. canaria* given in Brown & D'Almeida, 1970). The size of the egg of *D. relata* is closer to that of *C. canaria* while those of the other two genera (*Pteronymia* and *Hymenitis*) are smaller.

The coloration and extent of hair on body segments varies very strikingly when *Dircenna* (as seen by *D. relata*) caterpillars are compared to caterpillars of other genera such as *Hymenitis*, *Pteronymia*, and *Ceraticada*. While it is not necessary to go into a detailed account of these differences here, the caterpillars of *D. relata* are hairy while those of *H. nero*, *P. notilla*, and *C. canaria* generally lack hairs on body segments in all instars (see larval descriptions in Brown & D'Almeida, 1970; Young, 1972, in press, and present report). Furthermore, the color patterns of the body in caterpillars of *H. nero*, *P. notilla*, and *C. canaria* consist of a dark green background color with lighter lateral stripes, usually yellow or light blue; the color pattern of the caterpillars of *D. relata* is very different, being a linear patchwork of yellow spots on a light green and speckled background color (Fig. 2, B-E).

The pupae of these genera are also different. The major difference is in the extent of reflective coloration on the external surfaces. The pupa of *P. notilla* is generally devoid of gold or silver markings, with the color being translucent yellowish-green (Young, in press). The pupae of both *H. nero* and *C. canaria* are remarkably similar in terms of the highly reflective silver cover on the wings (Young, 1972; Brown & D'Almeida, 1970). The network of reflective gold coloration on the pupa of *D. relata* (Fig. 2,F,G) is different from the previous two color patterns. It is interesting that there occurs considerable similarity between the pupae of *Hymenitis* and *Ceraticada* since these genera belong to different tribes (Fox, 1940), while considerable divergence in appearance of the pupa occurs within the *Dircennini*, as typified by *D. relata*, *P. notilla*, and *C. canaria*.

Finally, it is interesting to consider some differences in larval and adult behavior among different genera. The ithomiid *Mechanitis isthmia* (see Fox, 1967) lays its eggs in tight clusters on the food plant (pers. obs., Costa Rica and El Salvador), but most other ithomiids in other

genera do not show this type of oviposition behavior. For example, *H. nero*, *P. notilla*, *C. canaria* generally lay their eggs singly but *D. relata* exhibits loose clustering of eggs (Fig. 2,A). The size and orderliness of egg clusters in *D. relata* are very different from *M. isthmia*. From recent considerations (Labine, 1968) it would seem that marked differences in oviposition behavior accompany differences in egg productivity of individual females in different species, and differences in the spatial distribution of preferred foodplants (for egg-laying) in different species. It is therefore difficult to obtain phylogenetic correlations for egg-laying behavior in butterfly groups such as the Ithomiidae.

It follows from the oviposition behavior that different genera have different degrees of larval gregariousness on the foodplant. The caterpillars of *M. isthmia* form very tight and coordinated groups on leaves of the foodplant (pers. obs.) in which there is group feeding and resting periods. This is very different from group organization in *D. relata* where each caterpillar is very individualistic for feeding, resting, and general locomotor activities. The more usually encountered situation, as seen in *H. nero*, *P. notilla*, and *C. canaria*, is where caterpillars occur singly on leaves and there is little or no evidence of group interaction of any sort when more than one individual is on the same leaf. For the ithomiids, it is clear that the degree of group interaction in caterpillars is a direct consequence of the type of oviposition.

#### SUMMARY

(1) The life cycle of the itomiid butterfly, *Dircenna relata* Butler & Druce, is described for the first time.

(2) The egg-adult developmental time on a natural foodplant, *Solanum hispidum* Pers. (Solanaceae) is about 25 days under constant laboratory conditions. But caterpillars are capable of successfully completing development on several other species of *Solanum*.

(3) The eggs are laid in loose clusters on leaves of the foodplant, and the number of eggs in each cluster is very variable. Eggs are generally laid on lower, older leaves and the caterpillars subsequently form loose, disorganized aggregations. There is no evidence of coordinated activity patterns (feeding, resting, etc.) among individuals within a "group." The loose association of the caterpillars is interpreted as a direct result of the loose clustering of eggs.

(4) An attempt is made to compare morphology, developmental time, and behavior patterns among different genera of Ithomiidae within the tribe Dircennini and outside it. In the absence of further data on these species and others, it is difficult to separate phylogenetic from contempo-

rary ecological selective forces for the characteristics studied. A plea is made for the bringing together of unpublished data on developmental time and foodplants as gathered by different workers in Central and South America, so that a more grandiose attempt to look for phylogenetic trends in these characteristics underlying population biology and habitat selection can be made.

#### ACKNOWLEDGMENTS

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THE GENUS *EUMAROZIA* HEINRICH (OLETHREUTIDAE)

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The genus *Eumarozia* was proposed by Heinrich (1926: 110) for the single species *Grapholitha* (*Poecilochroma*) *malachitana* Zeller, and until now, has remained monobasic.

The second species, described below, first came to our attention in 1970 and again in 1972, when it was submitted for determination. The third species which I now include in this genus was described by Meyrick. These species are of particular interest because they greatly extend the range of *Eumarozia*.

*Eumarozia malachitana* (Zeller)

Fig. 2

*Grapholitha* (*Poecilochroma*) *malachitana* Zeller, 1875, Verh. zool.—bot. Ges. Wien 25: 292.

*Penthina malachitana* (Zeller), Fernald, 1882, Trans. Amer. Ent. Soc. 10: 33 (no. 200); Fernald, 1891, in Smith, List Lepid. Bor. Amer., 91 (no. 4818).

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*Argyroploce malachitana* (Zeller), Barnes & McDunnough, 1917, Check List Lepid. North America, 168 (no. 6854).

*Eumarozia malachitana* (Zeller), Heinrich, 1926, U.S. Nat. Mus. Bull. 132: 111, figs. 60, 194, 413; McDunnough, 1939, Mem. So. Calif. Acad. Sci. 2(1): 40 (no. 6634); Jones, 1943, Lepid. Nantucket and Martha's Vinyard Islands, Mass., 149, 206; McKay, 1959, Can. Entomol. 91(Suppl. 10): 159, fig. 155; Kimball, 1965, Arthropods of Florida and Neighboring Land Areas. Lepid. Florida, 256 (no. 6634).

**Type:** British Museum (Natural History).

**Type locality:** Missouri.

**Distribution:** The species *malachitana* is widely distributed in the eastern and southern United States and its range extends into Mexico. According to specimens in the U.S. National collection and the collection of Dr. Annette F. Braun, Cincinnati, Ohio, the distribution is, alphabetically by states, as follows: ARKANSAS: Devil's Den State Park, Fayetteville (June); DISTRICT OF COLUMBIA: Washington (Sept.); FLORIDA: Lake Placid, St. Petersburg, Sarasota (Feb., Apr.); GEORGIA: Savannah (Aug.); ILLINOIS: Quincy (Sept.); INDIANA: Bedford (Sept.); KANSAS: Eureka, Pittsburg (June); MARYLAND: Hyattsville, Plummer's Island (Aug.); MISSOURI: Joplin, "Mtn. Grove," "C. Mo." (June); NORTH CAROLINA: Highlands, Knotts Is., Southern Pines (June, July); OHIO: Cincinnati (Sept.); OKLAHOMA: Oklahoma City (Sept.); TEXAS: Brownsville, Kerrville, Lk. Charlotte, San Benito (Apr.); VIRGINIA: Falls Church, Wicomico Ch. (Aug., Sept.). Heinrich (1926: p. 111) also recorded the species from "... Central America and South America." There are two specimens before me from Mexico from Salina Cruz, Oaxaca, and Orizaba (Wm. Schaus

coll.). I have seen none from South America. Presumably Heinrich accepted Zeller's original record "Sudamerica."

**Foodplants:** *Diospyros virginiana* L. (persimmon); *Ostrya virginiana* (Mill.) K. Koch (hop hornbeam); *Philoxerus* sp.; *Pyrus communis* L. (pear); *Cassia* sp. "black sapota" (*Achras*? sp.).

### **Eumarozia beckeri** Clarke, new species

Figs. 1, 3, 4

**Alar expanse** 13–15 mm. **Labial palpus** creamy white; third segment and outer side of second, light ochraceous buff. **Antenna** gray; cilia short, whitish. **Head** with face and vertex buff; posteriorly gray with white-tipped scales. **Thorax** grayish fuscous, tegula grayish fuscous, some scales white-tipped. **Forewing** ground color grayish fuscous; beyond basal fifth of ground color a shining buff transverse fascia extends from costa to dorsal margin, the dorsal third of fascia overlaid with leaden metallic scales; on costa, preceding the pale fascia, a triangular spot of grayish olive; the pale fascia is followed on its outer side by a transverse band of grayish olive, the latter edged outwardly with a narrow fascia of leaden-metallic scales; both grayish olive areas show a golden sheen in certain lights; outer half of wing deep hellebore red variously marked with fuscous; from end of cell at about vein 5, a crescentic fuscous mark ending on termen; on tornus a quadrate fuscous spot and a fuscous blotch between the latter and the crescentic mark; subterminally a curved line of small leaden-metallic spots; around termen a series of 5 or 6 fuscous dots; cilia fuscous with some red scales mixed. **Hindwing** grayish fuscous, slightly darker toward termen; extreme costal edge of male buff, followed inwardly with a longitudinal band of black scales; cilia grayish with a darker subbasal line. **Foreleg** gray strongly suffused fuscous on outer side; tarsal segments spotted with white; **mid- and hindlegs** leaden gray. **Abdomen** grayish fuscous to leaden gray with a few scattered buff scales ventrally and in tuft.

**Male genitalia** (USNM 24095): Harpe with deeply incised neck; cucullus rounded, broad; Spc<sup>1</sup> a single long seta; Spc<sup>2</sup> absent; base of cucullus with series of strong setae; ventral edge of sacculus with cluster of long setae and inner surface setaceous. Gnathos a moderately broad band. Uncus reduced, rounded. Socius a setaceous lobe at end of flattened stalk. Vinculum broadly rounded. Tegumen oval. Anellus subtriangular strongly attached posteriorly to a scoop-shaped member through which the aedeagus articulates. Aedeagus slender, curved; vesica armed with a cluster of long cornuti.

**Female genitalia** (USNM 24096, 24097): Ostium produced dorsally, nearly rectangular. Antrum not differentiated. Inception of ductus seminalis from anterior end of ductus bursae, slightly posterior to junction with bursa copulatrix. Ductus bursae sclerotized for most of its length, slender. Bursa copulatrix membranous. Signa two triangular plates with serrate edges.

**Holotype:** USNM No. 72436.

**Type locality:** Costa Rica, Turrialba.

**Distribution:** Costa Rica.

**Foodplant:** *Juglans olanchanum* Standl. & L. Wms.

Described from the holotype ♂, 55 ♂♂ and 55 ♀♀ paratypes from the type locality dated 29 August to 3 October 1972, V. O. Becker; and 2 ♂♂ paratypes Costa Rica, Turrialba (12 January 1970), no collector, rf. *Juglans*. Paratypes are distributed as follows: 5 ♂♂, 5 ♀♀ (25–30 September 1972) in Museu de Entomologia de la Universidad de Costa Rica; 48 ♂♂, 48 ♀♀ (9 September–3 October 1972) Becker Collection in the Department de Zoologia da Universidade Federal do Paraná, Brasil; 2 ♂♂, 2 ♀♀ (12 January 1970 and 29 August 1972), U.S. National Museum.

The two species treated here are closely allied but may be distinguished



1



2

Fig. 1. *Eumarozia beckeri*, new species. Turrialba, Costa Rica. Fig. 2. *Eumarozia malachitana* (Zeller). Devil's Den State Park, Arkansas.



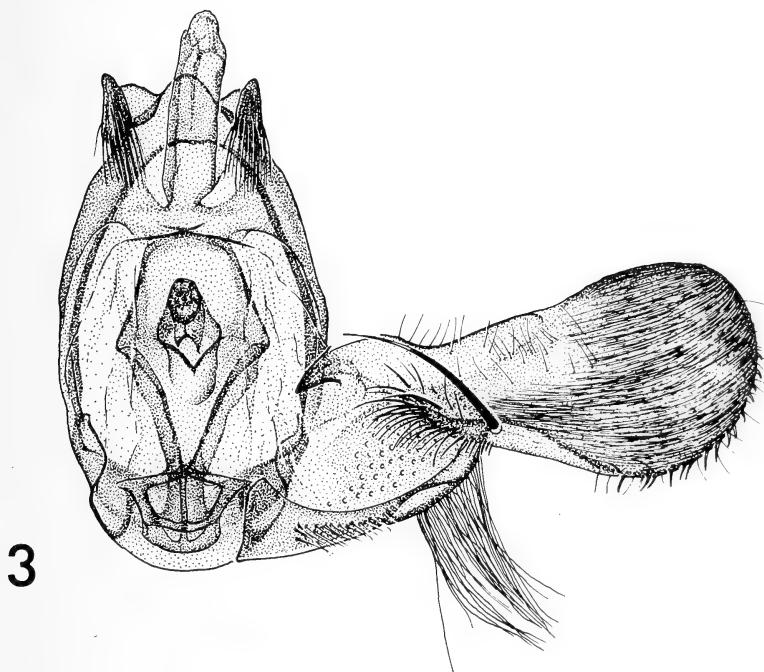


Fig. 3. *Eumarozia beckeri*, new species. Ventral view of male genitalia with left harpe omitted.

easily on pattern and genitalia. In *E. malachitana* the olive marking near center of forewing is nearly oval in shape, does not reach the dorsal edge and is bordered by a slender buff or white line. In the case of *beckeri*, however, the olive marking is in the form of a transverse fascia which reaches from costa to dorsum. The male genitalia are similar;  $\text{Sp}^1$  (Heinrich, 1926: fig. 60) being prominent in both species; but  $\text{Sp}^2$  is absent in *beckeri*. The only substantial difference between the female genitalia lies in the size and shape of the ostium which is much narrower and longer in *beckeri* than in *malachitana*.

It gives me great pleasure to name this species in honor of Victor Omar Becker who collected and reared the major part of the type series.

*Eumarozia elaeanthos* (Meyrick), new combination

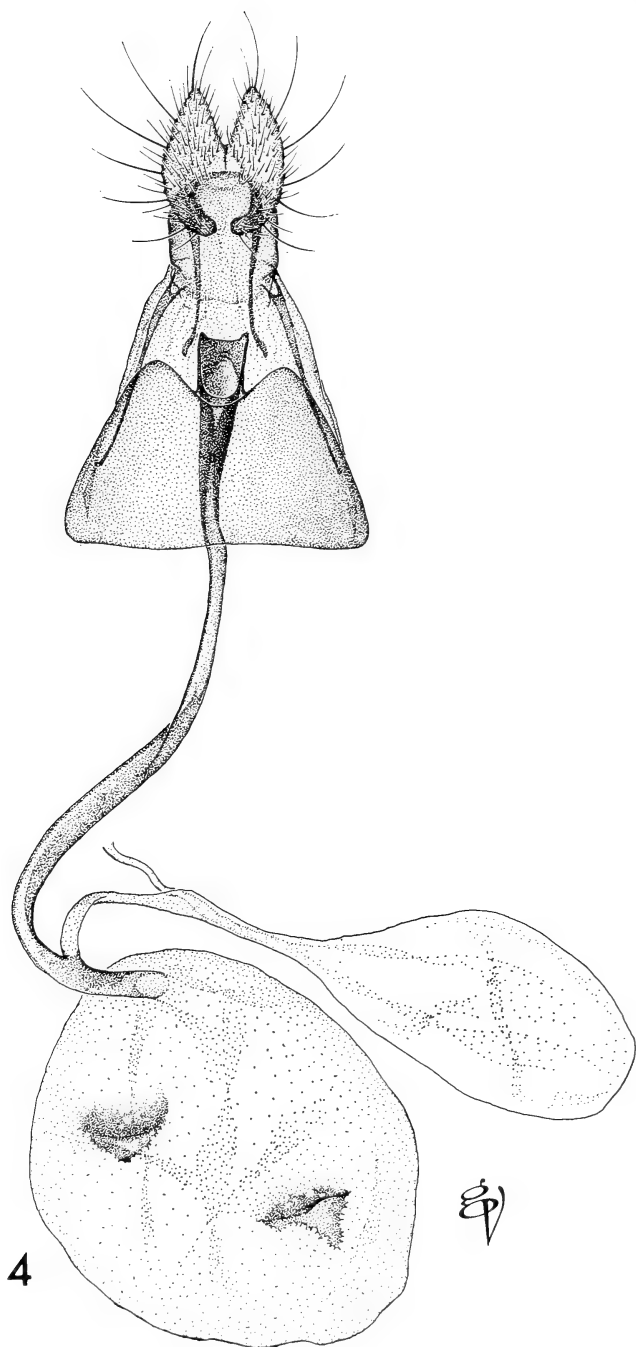
*Argyroproce elaeanthos* Meyrick, 1927, Exotic Microlepid. 3: 340.

*Olethreutes elaeanthos* (Meyrick), Clarke, 1958, Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick, 3: 507, pl. 252, figs. 1-1a.

**Type:** British Museum (Natural History).

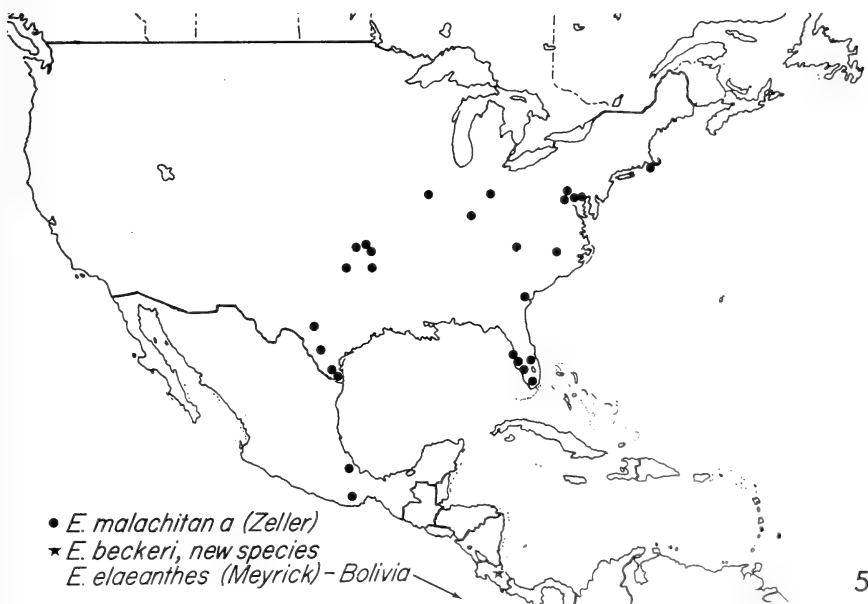
**Type locality:** Bolivia, Andes, 10,000 feet.

**Distribution:** Known only from the type locality.



**Foodplant:** Unknown.

Meyrick described *elaeanthus* from the unique type, and as far as I know, the type is the only known specimen. The genitalia of the male *elaeanthus*, which I figured (1958: pl. 252, figs. 1-1a), are typical for the genus except  $Spc^2$  (Heinrich, 1926: fig. 60) is missing, as in *beckeri*. Inside costa, at basal third of harpe, is a cluster of strong setae, and from the ventral edge of sacculus is a series of long, hairlike setae in *elaeanthus* which are absent in *malachitana*. In the forewing of *elaeanthus* there is no white line delineating the olive green area as in *malachitana*. I have not figured *elaeanthus* here; the figure cited is adequate for recognition.



5

Fig. 5. *Eumarozia* distribution.

#### ACKNOWLEDGMENTS

The photographs for this paper were made by Victor E. Krantz and the drawings were made by George Venable, both on the staff of the Smithsonian Institution.

←

Fig. 4. *Eumarozia beckeri*, new species. Ventral view of female genitalia.

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THREE NATURAL HYBRIDS OF *VANESSA ATALANTA RUBRIA*  
× *CYNTHIA ANNABELLA* (NYMPHALIDAE)

THOMAS E. DIMOCK

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In an effort to better understand the relationship and variation of two local butterflies, *Vanessa atalanta rubria* (Fruhstorfer) and *Cynthia annabella* Field, not only as adults but also as larvae, I have been rearing to maturity all vanessid larvae encountered on their various foodplants. In the vicinity of northeastern Thousand Oaks, California, foodplants for *C. annabella* are *Althaea rosea* (L.) Cav. (Hollyhock), *Malva parviflora* L. (Cheeseweed), both Malvaceae; and *Urtica holosericea* Nutt. (Stinging Nettle), Urticaceae. *Urtica holosericea* grows abundantly along an intermittent creek, which flows through the Lang Ranch property, and is the only local foodplant for *V. a. rubria*. The surrounding floral communities are coastal sage scrub, chaparral, southern oak woodland (Munz, 1968), and annual pasture grassland. The area is but a half mile from city subdivisions.

On 3 April 1972 I collected two second instar larvae on two *Urtica* plants occupying a position further downstream than any other *Urtica*. Several leaves were taken as a food supply. In later instars both larvae appeared at a glance to be *C. annabella*, so when all the *Urtica* leaves were consumed the larvae were given leaves of *Althaea rosea*, which they readily devoured to maturity. At this time one larva hung and pupated, and later emerged as *C. annabella*. The other continued growth and surpassed in size all other *C. annabella* reared to date. Finally it pupated, and when the hardened pupa was observed, characteristics of

both *V. a. rubria* and *C. annabella* were displayed. I then decided it would be wise to take some notes of description in case the specimen proved to be a hybrid, which it was. It is regrettable that closer attention was not given to the larva, but as it fed and simply appeared to be *C. annabella*, it was assumed to be merely a giant individual. Therefore, the following larval description is written from memory and is very general.

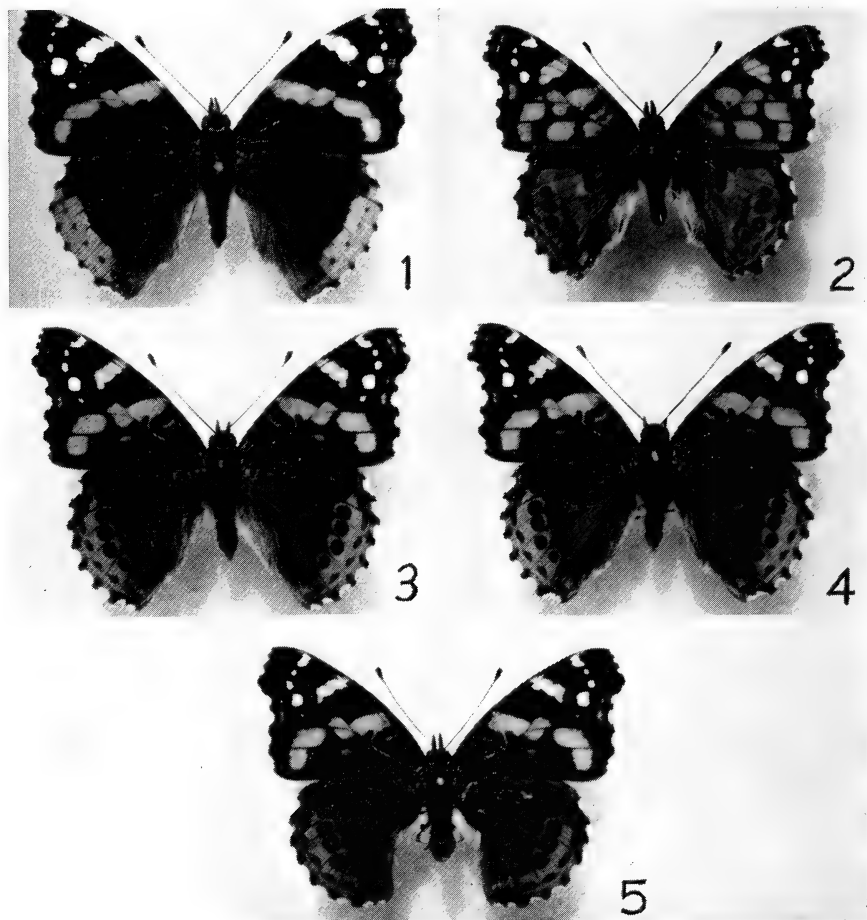
**Hybrid #1. Mature larva.** Coloration within usual range of variation shown by *C. annabella* and *V. a. rubria*. A dark form, ground color dark grey, with a series of indistinct subdorsal black patches (as in some *V. a. rubria*). Supralateral rusty-orange coloration, typical of many *C. annabella*, very reduced. Lateral line dull flesh-colored. Spines black. Shape as in *C. annabella*. **Pupa.** Shape as in *V. a. rubria*, abdominal segments flattened laterally but not to extent shown by *V. a. rubria*. Ground color tan or light brown. Most obvious features are subdorsal pair of white spots on metathorax, first, and second abdominal segments ("saddle spots") (these are bright gold in *V. a. rubria* and white in *C. annabella*). Also a subdorsal pair of smaller white spots on mesothorax, and middorsal point on this segment lighter than ground color. The pair of subdorsal points, and the single row of middorsal points on abdominal segments 3 through 7, dull orange. Supralateral gold spot which occurs on many *V. a. rubria* on the fourth abdominal segment here present only as yellowish spot lighter than ground color. Grey lateral line on the abdominal segments. Only marking on wing case a thin, black vein line on discal cell at base of  $M_2-Cu_1$ . Pupal measurements: length 21 mm, width 8 mm, depths: thorax 8 mm, saddle 6 mm, abdomen 8 mm. (For comparison, pupal measurements of the parent species (average of five specimens each) are: *V. a. rubria*: length 21.7 mm, width 8 mm, depths: thorax 8 mm, saddle 6.3 mm, abdomen 8 mm. *C. annabella*: length 19 mm, width 7 mm, depths: thorax 6.25 mm, saddle 5.25 mm, abdomen 7.25 mm.) Pupal duration, 9 days at room temperature. *V. a. rubria* and *C. annabella* both have pupal durations of 8 to 9 days at room temperature.

Following the pupation of this first individual, with the realization that it was a hybrid, I returned to the foodplant locality and collected all remaining larvae. Eleven were found: two hybrids and nine *V. a. rubria*. Again, however, the hybrids were not suspected until after the final moult. These two individuals differed from the previous hybrid, so brief descriptions are given for both.

**Hybrid #2. Mature larva.** Ground color black as in some *V. a. rubria*. Lateral line pale yellow. Head entirely black. Spines black. Otherwise like *V. a. rubria*. **Pupa.** As in hybrid #1. Pupal measurements: length 21.3 mm, width 7.5 mm, depth: thorax 7.5 mm, saddle 6 mm, abdomen 7.5 mm. Pupal duration 8 days.

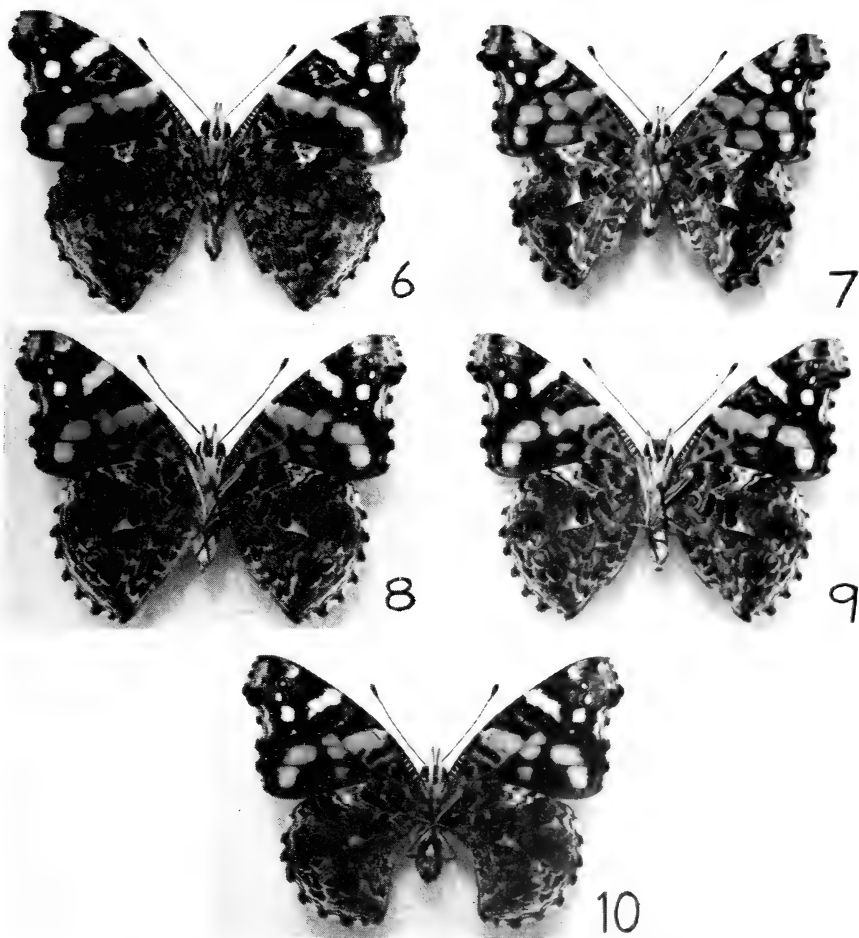
**Hybrid #3. Mature larva.** Ground color dark brown with numerous tiny yellow spots laterally and dorsally except for narrow middorsal line of solid ground color. A rusty-orange spot on each abdominal segment between subdorsal and supralateral spines. Lateral line large and yellow, interrupted at each segment by a lateral spine base of the ground color. Head entirely black. Spines black. Shape as in *C. annabella*. **Pupa.** As in hybrid #1. Pupal measurements: length 20 mm, width 7 mm, depths: thorax 7 mm, saddle 5.5 mm, abdomen 7 mm. Pupal duration 8 days.

Adult hybrids #1 and #2 emerged without problems. Hybrid #3 had



Figs. 1-5. *Vanessa atalanta rubria*, *Cynthia annabella*, and three natural hybrids: (1) *V. a. rubria*, male, ex-larva on *Urtica holosericea*, northeast Thousand Oaks, Ventura Co., Calif., elev. 980 ft., 17 April 1972; (2) *C. annabella*, male, ex-larva on *U. holosericea* plus *Althaea rosea*, northeast Thousand Oaks, Ventura Co., Calif., 3 April 1972; (3) hybrid #1, male, same data as *C. annabella*; (4) hybrid #2, male, same data as *V. a. rubria*; (5) hybrid #3, male, same data as *V. a. rubria*.

to be assisted by the author, at the expense of the pupal shell, from the terminal four pupal shell segments, as these failed to separate from the body of the adult. During the last day of pupal duration the abdomen failed to darken while coloring developed normally over the remainder of the pupa. Probably as a result of this trouble, the butterfly, after extraction from the pupal shell, failed to expand its hindwings to their full extent.



Figs. 6-10. Undersides of corresponding specimens in Figs. 1-5.

Figs. 1-10 depict the parent species and the three hybrid specimens. The color of the subapical bar on the forewing upperside is white in *V. a. rubria* and orange in *C. annabella*. In the hybrids this bar is only slightly lighter orange than in *C. annabella*. An interesting feature on the underside of the left forewing of hybrid #3 is a streak of orange in the apical area. All three hybrids are males.

It is remarkable that hybrids of *V. a. rubria* and *C. annabella* occur in nature, and I can only speculate on the circumstances responsible for their production. Both species are hilltoppers, and it has been shown by Shields (1967) that fertilization of the females takes place on hilltops.

It seems safe to assume that when males of both species are on a given hilltop they court and fertilize females of their own species. If, however, a virgin female of one species hilltopped and found the summit occupied only by one or more males of the other species, interspecific courtship, copulation, and fertilization *might* then occur. There must certainly be many behavioral and environmental factors opposing this process, otherwise one might expect hybrids to be more common.

Field (1971) has removed *annabella* from the genus *Vanessa* and placed it in *Cynthia*. In view of the natural hybridization of *V. atalanta rubria* and *C. annabella*, it would seem that the validity of such a separation is doubtful. Until further studies of the hybrids can be made, including laboratory crosses and backcrosses, together with comparative morphological studies of the early stages, it seems best to respect for the present Field's revision.

The adult hybrid specimens, their mature larval cast skins, and the pupal shells of hybrids #1 and #2 are retained in the collection of the author.

#### ACKNOWLEDGMENTS

I am most grateful to Mr. Herman G. Real of San Mateo, California, for his review and criticism of the manuscript, and to Dr. Theodore D. Sargent for his editorial suggestions.

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#### NOTES AND NEWS

##### *Erratum*

In my paper, "Observations on some Phycitinae (Pyralidae) of Texas with descriptions of two new species," (J. Lepid. Soc. 24: 249-255, 1970), the species *Dioryctria Auranticella* (Grote) is reported in error. Dr. E. G. Munroe, who saw the three specimens, when he examined my collection in early 1973, identified them as *Dioryctria rossi* Munroe.



LIFE HISTORY OF *CALLOPHRYS S. SHERIDANII* (LYCAENIDAE)  
AND NOTES ON OTHER SPECIES<sup>1</sup>CLIFFORD D. FERRIS<sup>2</sup>

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Although *Callophrys sheridanii sheridanii* (Edwards) (see Brown & Opler, 1970, concerning authorship) was described in 1877, little was known until recently about its life history. Eff (in Brown et al., 1957) reported the foodplant as *Eriogonum umbellatum* Torr. The type locality for this butterfly is "Big Horn Mountains," near Sheridan, Wyoming. The present study is based upon live material collected in the vicinity of Pole Mountain (East of Laramie), Medicine Bow National Forest, ca. 8500', Albany Co., Wyoming, April-May, 1971-72.

A few ova of *C. sheridanii* were secured in the field. Live females were captured and caged over the hostplant. Very few additional ova were obtained in this manner, however, as the females were very reluctant to oviposit in captivity, even when placed with the foodplant and various nectar sources in a large breeding cage out of doors.

Females appear to oviposit selectively upon *E. umbellatum*. No ova or signs of larval feeding were observed upon two other species of *Eriogonum*, *E. flavum* Nutt. and *E. subalpinum* Greene, which are sympatric with *E. umbellatum*. In the field, ova were found on the largest of the plants only. Only one or two eggs were found per plant.

In April and May, when the ova are deposited, *E. umbellatum* is a low-growing trailing plant. Some plants spread out to a foot or more in diameter. The rosettes are not yet well developed, and the foot-high flower stalks do not appear until June and July. The plant is quite common on open hillsides in the Transition Zone in various areas of Wyoming.

## Description of Immature Stages

**Ovum:** Eggs a very pale green, oblate spheroids approximately 0.8 mm in diameter; laid singly at the base of a leaf rosette, on the upper surface of the stem; color blends with color of new buds on the plant. Depending upon temperature, eggs may remain up to a week before hatching. Prior to emergence of larva, ova turns a milky white.

**First Instar:** First instar larvae pale greenish-white and covered with long fine black hairs; head light green. Larvae do not eat egg shells. Stadium one lasted 2-3 days and larvae increased in length from about 1-3 mm.

<sup>1</sup> Published with the approval of the Director, Wyoming Agricultural Experiment Station, as Journal Article JA 560.

<sup>2</sup> Research Associate, Allyn Museum of Entomology, Sarasota, Florida.

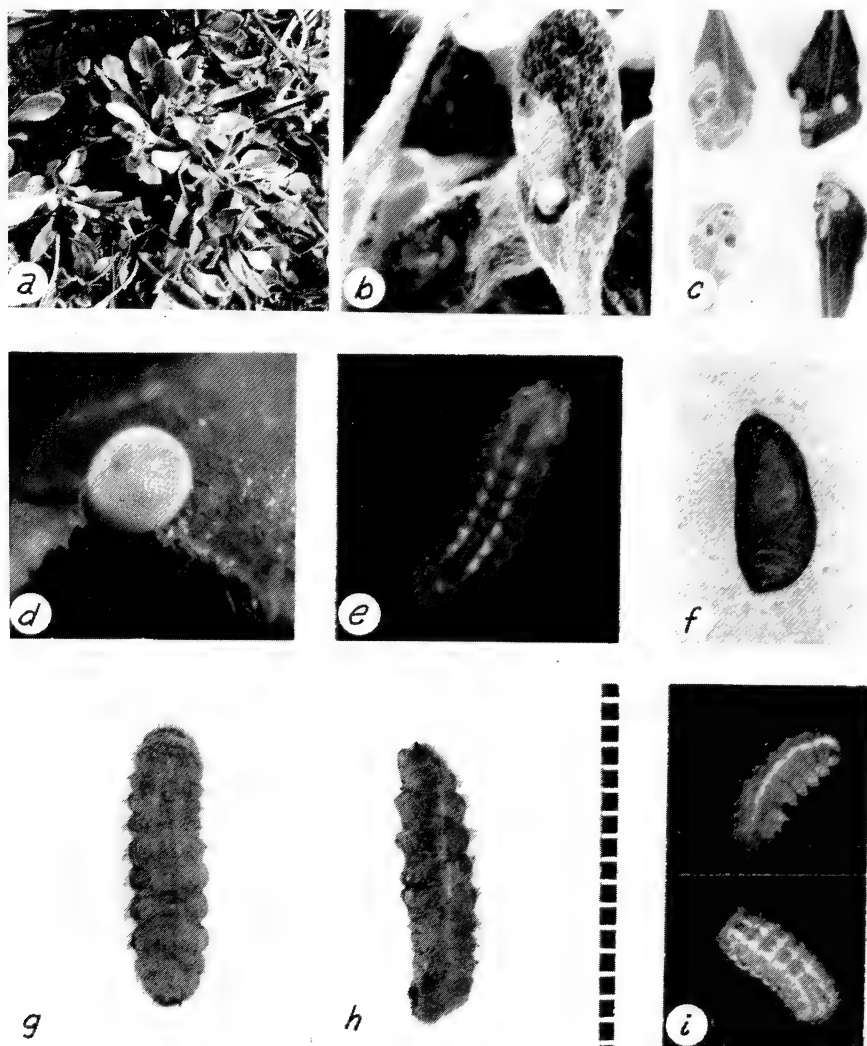


Fig. 1. *Callophrys s. sheridanii* and its foodplant: (a) *E. umbellatum* (in situ) as it appears in April; (b) leaf damage (in situ) produced by *sheridanii* larva; (c) larva-damaged leaves; (d) ovum of *C. s. sheridanii*; (e) early 4th instar larva; (f) pupa; (g) mature (4th instar) larva, dorsal view; (h) same, lateral view, scale divisions are 1 mm; (i) dorsal and lateral views of late third instar larva.

**Second Instar:** Stadium two larvae a uniform green, covered with short, stiff black-tipped spines; black dots visible at bases of spines. This stage lasted from 3–4 days and larvae increased in length to 5 mm.

**Third Instar:** Third instar larvae similar to second instar, but stiffer spines, pink at base. As larvae matured, two rows of luminous white spots appeared (Fig. 1, i);

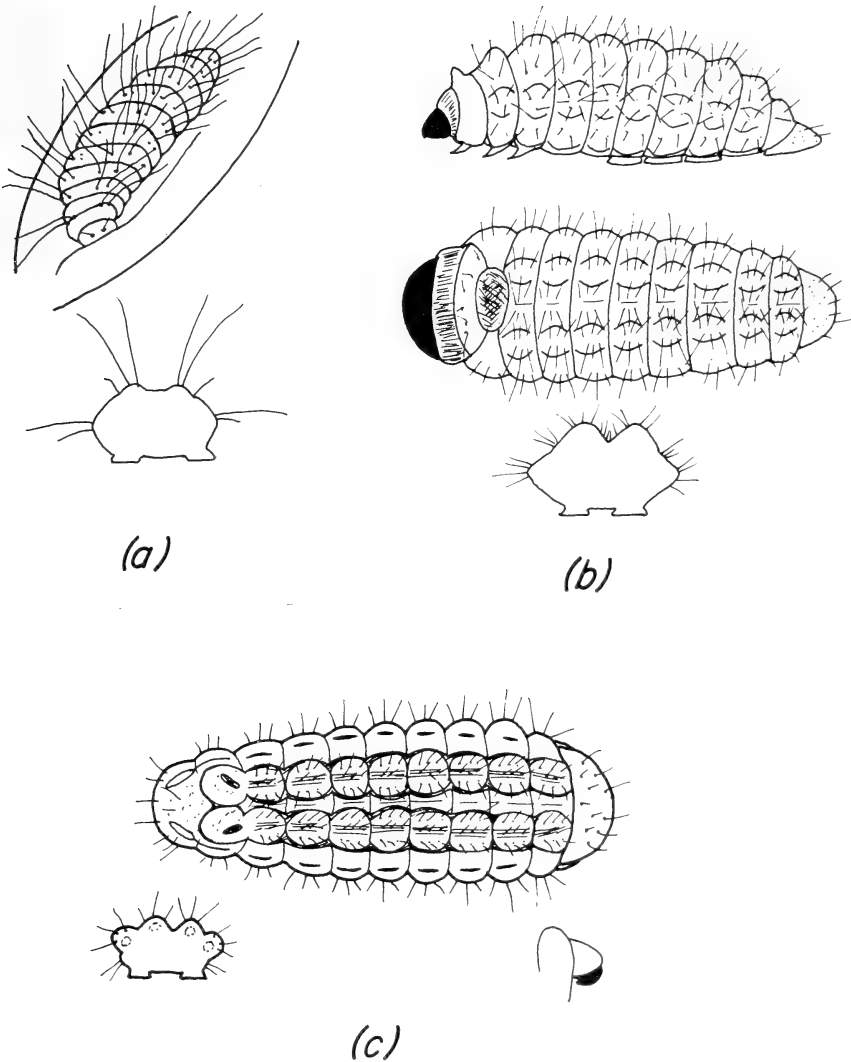


Fig. 2. *Callophrys s. sheridanii*: (a) 1st instar larva feeding, and cross-section through a middle segment; (b) lateral and dorsal views of 2nd instar larva, and cross-section through a middle segment; (c) dorsal view of 3rd instar larva, and cross-section through a middle segment, also lateral view of head (black) tucked under frontal segment.

not surface spots, but appearing to be well below skin surface. Stadium three lasted approximately two weeks and larvae increased in length to 0.9–1 cm.

**Fourth Instar:** Fourth instar larvae similar to third, but white spots attenuated and gradually fading as larvae matured. Green color approximately matched that

of fresh leaves of foodplant. Including prepupal stage, stadium four lasted about three weeks, and larvae increased in size to about 1.5 cm.

**Pupa:** Pupae medium brown color and covered with short brown hairs. No other distinguishing characters. Measured 0.8–0.9 cm. Pupation occurred on the earth in debris at bottom of rearing container.

The larvae exhibited rather peculiar feeding habits. Rather than consuming the leaves of the foodplant from the edges or tips, they ate holes from the under or upper surfaces of the leaves into the leaf centers. On the untouched sides, the leaves appeared to have been attacked by leaf mining insects, but when turned over, the larvae-produced holes could be seen. Fig. 1 (b,c) illustrates leaf damage. This characteristic feeding pattern, which persisted through all larval instars, aided in discovering larvae in the field.

Larvae were not observed to spin silken mats prior to moulting, as do some other Theclinae larvae, nor did they eat the cast-off skins.

During rearing, larvae were maintained at 20° C, which is a somewhat higher temperature than that of the natural habitat.

#### Notes on Other Species

It was observed that two other genera of Lepidoptera use *E. umbellatum* as a larval host. While collecting ova of *C. sheridanii* in May 1971, a mature lycaenid larva was found feeding on *E. umbellatum*. It was a medium green color with a lateral pink and white stripe. At first this was thought to be a mature *sheridanii* larvae, as ova can be found throughout the month-long flight period of the adults. The larva pupated and a male *Plebejus (Icaricia) acmon lutzi* Klots emerged in July 1971. Apparently this species must overwinter in the third or fourth instar, as adults are not on the wing until June in the Pole Mountain area, and very cold weather prior to collection of the larva precluded development from an egg.

As mentioned previously, larvae of *C. sheridanii* were field-collected in 1972 by looking for the characteristic leaf damage they produce. It was also found that a moth larva produces the same sort of damage. Efforts to obtain adults from these larvae were unsuccessful. They were leaf-rollers and spun a light silken network in their feeding area. They had black heads and were about the same color as *sheridanii* larvae.

On 11 July 1971, females of *Callophrys sheridanii neoperplexa* (Barnes and Benjamin) were observed ovipositing on *Eriogonum umbellatum* var. *dichrocephalum* Gand. on the rocky hillsides about 1–2 miles southeast of Galena Summit, ca. 8200', Blaine Co., Idaho. The ova were similar to those of *C. s. sheridanii*. Rearing was not attempted.

## ACKNOWLEDGMENTS

Appreciation is expressed to Dr. John M. Reeder, University of Wyoming, Laramie, and to Dr. James L. Reveal, University of Maryland, College Park for determining the species of *Eriogonum* cited, and to Mr. Michael M. Ellsbury, Ft. Collins, Colorado, who assisted in the care of the larvae and provided the photographs shown in Fig. 1 (e and i).

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## DOWN-VALLEY FLIGHT OF ADULT THECLINI (LYCAENIDAE) IN SEARCH OF NOURISHMENT

JAMES A. SCOTT

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Down-valley movement of adult Theclini was reported by MacNeill (1967) for *Satyrrium saepium* Boisduval. In this paper I will report down-valley flight of four additional species and will show the presumed flight pattern (Fig. 1) and the purpose of the down-valley flight.

There are two types of mate-locating behavior among males of butterflies (Scott, in press). In *perching* species, males sit at characteristic sites and dart out at passing objects in search of females, often returning to or near the previous spot after an investigative flight. Virgin females fly to these mating sites after emergence. In *patrolling* species, males fly almost constantly in search of females.

Down-valley flight is defined as continuous rapid flight predominantly in a down-valley direction. Such flights can occur for several reasons, including migration. In patrolling species, male patrolling may appear similar to down-valley flight, but differs in that males investigate females, flight upstream occurs about as frequently as downstream, and males usually patrol on hillsides in addition to valleys. Females may have different flight behavior in the two situations. In this paper I show that down-valley flight is part of a feeding response (Fig. 1).

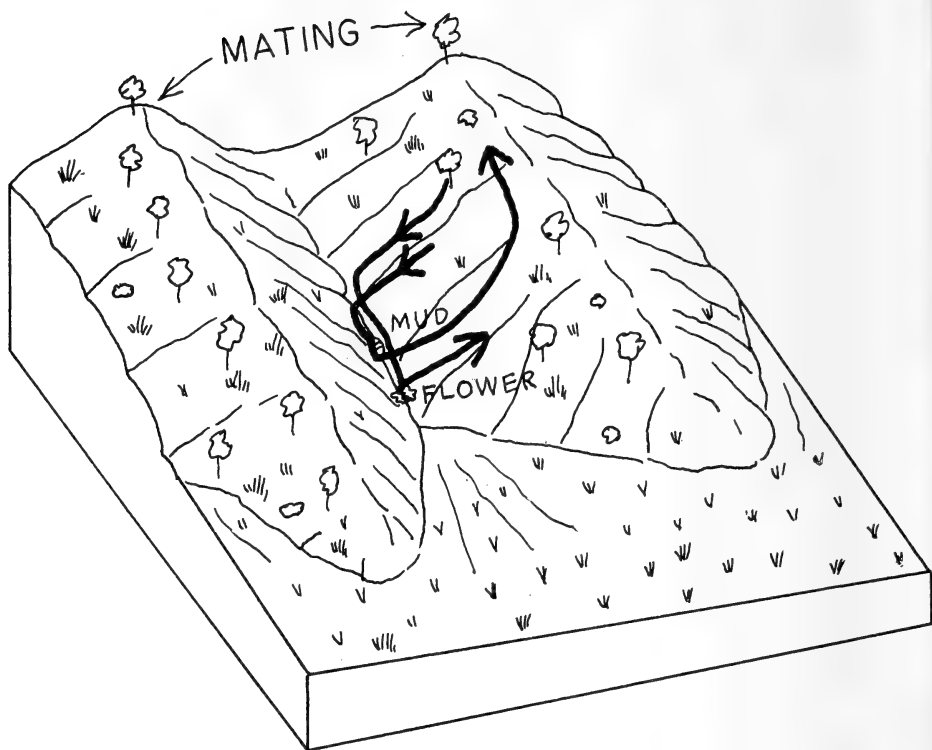


Fig. 1. Postulated flight pattern of two adult Theclini in search of nourishment.

#### METHODS AND RESULTS

Down-valley flight of *Callophrys johnsoni* Skinner, *Callophrys augustinus* Westwood, and *Atlides halesus* Cramer was observed 18, 19, 20, and 21 March 1972 at Thompson Canyon, Yolo County, California. Behavior of the three species was identical. *C. augustinus* was only about two-thirds as abundant as *C. johnsoni*, and *A. halesus* was uncommon. The interval between the appearance of individuals passing the stationary observer averaged about 10 minutes for *C. johnsoni* on 18 March, and increased to about 25 minutes on 21 March, as abundance declined. These intervals for *C. augustinus* were about 15 minutes, increasing to about 30 minutes. Because observations were made near the end of the brood, both species declined in numbers with time. Weather was similar on all four days, and so did not affect the observed numbers. Only about five *A. halesus* were seen per day. Individuals flew down-valley about a meter about the ground at a rapid rate of perhaps 3 meters per second for both *Callophrys* species; *Atlides* flew slightly faster. Very few in-

dividuals of these species flew up-valley. Individuals were observed flying far enough apart so that they could seldom see one another in flight. They flew down-valley from about 0930 to 1600 on all days, but most individuals were observed between 1200 and 1400, the warmest part of the day. Where the road along the stream bottom ran onto the hillside, individuals flew along the stream bottom rather than the road.

Down-valley flight of *Erora laeta quaderna* Hewitson was observed on 6 April 1966 near Stewart Campground, Cochise County, Arizona. Down-valley flight of both sexes was the same as that of the *Callophrys* species except that individuals flew down-valley mainly along a road in the canyon bottom. Down-valley flight also occurred mainly in warm midday hours.

*C. johnsoni* males and females fed in the valley bottom on mud and on flowers of *Rhus trilobata* Nutt., and (rarely) on *Cercis occidentalis* Torr. *C. augustinus* fed there on mud and on *Rhus*. *A. halesus* and *E. laeta* Edwards fed on mud.

Females outnumbered males in the two *Callophrys* species. Observed sex ratios based on collections by several persons during the 4 days were: *C. johnsoni*, 33♂, 59♀; *C. augustinus*, 15♂, 45♀; *A. halesus*, 2♂, 2♀. The sex-ratio of *E. laeta* was 32♂, 31♀.

#### DISCUSSION AND CONCLUSIONS

Down-valley flight among Theclini has been recorded previously only at high population density. MacNeill (1967) observed down-valley flight of *Satyrium saepium* in a small dry ravine. About 5–15 individuals per minute flew down-valley about a meter above the ground, from 1130 to 1200; very few individuals flew up-valley. The present observations indicate that the phenomenon may be widespread at fairly low density in Theclini, but is seldom noticed except at high density.

The continuous down-valley flight contrasts markedly with the short flights characteristic of mate-locating behavior. All five species are perching species. Details of mate-locating behavior of these species follow:

- 1) Oakley Shields (pers. comm.) observed mate-locating behavior of *C. johnsoni* on a hilltop next to Thompson Canyon, where many males perched on the tops of tall trees, from which they often chased each other. I observed the same behavior in the closely related species *C. spinetorum* Hewitson occurring on small pines near hilltops in Grand Canyon, Arizona, in the afternoon.

- 2) Powell (1968a) described mate-locating behavior of *C. augustinus*. Males perched on a small tree in a clearing from 1030 to dusk. Mating

was observed only in the late afternoon. However, I observed copulation at 1110 on a tree on a hillside at Alpine Lake, Marin County, California, 4 April 1970.

3) I have observed many *A. halesus* males perching on the tops of small trees on hilltops at midday and in the afternoon at four localities in New Mexico and Arizona.

4) Many *E. laeta* males were observed perching on the tops of juniper trees on hilltops in the afternoon near Emory Pass, Sierra County, New Mexico, 5 April 1966, and near Onion Saddle, Cochise County, Arizona, 6 April 1966 and 24 April 1973.

5) I observed mate-locating behavior of *S. saepium* at numerous localities in Jefferson County, Colorado, where males perched about one meter above the ground on the sides of small pine and juniper trees on ridgetops and hilltops. Males perched mostly on the eastern side of trees in the morning, and on the western side in late afternoon. The preferred side was less predictable at midday, but males often chose the south side. The perching males darted after passing objects (mainly other males) and usually returned to the same tree after an investigative flight. Such behavior occurred from 0715 to 1600. A copulating pair was found at 1155 on one of the trees where males were perching.

The presumed flight pattern is shown in Fig. 1. Individuals fly from hillsides to the valley bottom, then downstream to a feeding site. Having fed, they depart to the hillsides again. The following points support these contentions: 1) individuals were most abundant in a small area in the middle of Thompson Canyon; only one individual was seen at the mouth of the canyon, and only one (a female showing preoviposition behavior toward the larval hostplant) was seen near the head of the canyon; (MacNeill (1967) also noted that down-valley flight was confined to a small area); 2) study on four consecutive days showed that individuals do not move down-valley one day and up-valley the next. More than 20 individuals of each of the two *Callophrys* species were seen to fly down-valley each day, whereas less than 4 per day flew up-valley.

Down-valley flight may be advantageous to these species because flowers and water are often more abundant in the central portions of small canyons in arid areas of the western United States. Down-valley flight may prove to be limited to arid areas, since it involves movement toward regions of high moisture. Individuals need to seek nourishment in the valley bottom because flowers are much less common on hillsides. Also, larval hostplants grow on hillsides, and do not serve as nectar sources for the adult butterflies. The known larval hostplants are as follows: *Arceuthobium campylopodum* Engelm. for *C. johnsoni*, a plant



parasitic on *Pinus sabiniana* Dougl. in Thompson Canyon (Shields, 1965); many plants for California *C. augustinus* (Powell, 1968b); *Phoradendron* for *A. halesus*, a plant parasitic on live oak; and *Ceanothus* sp. for *S. saepium* (Clench, 1961).

Net down-valley movement was not observed for either sex in any of the species. The flight pattern postulated in Fig. 1 does not result in net down-valley movement, because individuals of at least *C. johnsoni*, *A. halesus*, *E. laeta*, and *S. saepium* apparently move upslope to seek mates on hilltops. Scott (1973) and Shields (1967) have shown that hilltops serve as mating sites for some butterflies.

Finally, down-valley flight also probably occurs in other butterfly taxa. I have observed what appears to be down-valley flight in *Oeneis chryxus* Doubleday and *O. uhleri* Reakirt (both Nymphalidae, Satyrinae) in southern Colorado. However, about 20–30 percent of the individuals of these species seen were flying upstream; individuals of these two species also were observed feeding on mud in the gully bottom.

#### SUMMARY

Down-valley flight (continuous rapid flight predominantly in a down-valley direction) was observed in four species of Theclini and appears to be part of a behavior pattern in which individuals seeking nourishment fly to the valley bottom, fly downstream until mud or flowers are found, feed, then fly to hillsides. Mate-locating behavior, which occurs elsewhere (usually on hilltops), is very different.

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THE IDENTITY OF *MACARIA INAPTATA* WALKER AND  
*ITAME VARADARIA* (WALKER) (GEOMETRIDAE)

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*Macaria inaptata* Walker has been consistently misidentified since the time of its original description. In North American lists it was treated as a variety of *Episemasia solitaria* (Walker) by early authors following Hulst (1894: 306). More recently the name has stood as that of a distinct species in the *Semiothisa minorata-distribuaria* group, having been arbitrarily transferred to *Semiothisa* when *Macaria* was recognized as a junior synonym (e.g. McDunnough, 1938: 158). In the collection at the U.S. National Museum I found a finely executed colored drawing of a moth resembling *Semiothisa aemulataria* (Walker), but mislabelled as the type of *Macaria inaptata*. This illustration appears to represent an unnamed species that I was preparing to describe, and it thus led to the present investigation. When I recently examined the type of *inaptata*, I found that it is actually a female of *Itame varadaria*; thus *Macaria inaptata* Walker, 1861: 886, becomes a synonym of *Caberodes* ? *varadaria* Walker, 1860: 251.

At least three other names have been proposed for this species, and its synonymy and type data are as follows:

*Itame varadaria* (Walker)

*Caberodes* ? *varadaria* Walker, 1860, List of the Specimens of Lepidopterous Insects in the Collection of the British Museum 20: 251.

**Type locality:** Georgia (From the Milne collection and probably collected by Abbot).

**Types:** A male holotype in the collection of the British Museum (Natural History).

*Macaria inaptata* Walker, 1861, *ibid.* 23: 886. NEW SYNONYM.

**Type locality:** United States. As the species is known only from the extreme Southeast, and the donor was stated to be Doubleday, I hereby restrict the type locality to St. Johns Bluff, Duval Co., the site of Doubleday's Florida collecting.

**Types:** A female holotype in the collection of the British Museum (Natural History).

*Aspilates abbreviata* Walker, "1862"[1863], *ibid.* 26: 1673.

**Type locality:** Georgia (from the Milne collection and probably collected by Abbot).

**Types:** A male holotype in the collection of the British Museum (Natural History).

*Diastictis florida* Hulst, 1896, Trans. Amer. Entomol. Soc. 23: 334.

**Type locality:** Florida.



Figs. 1-3. *Itame varadaria* (Wlk.): (1) summer brood male, Wedge Plantation, McClellanville, South Carolina, 19 August 1971; (2) spring brood male, same locality, 31 March 1967; (3) spring brood female, University Conservation Reserve, Welaka, Putnam Co., Florida, 11 March 1962. (All collected by the author.) Photos by photographic laboratory of the Smithsonian Institution.

**Types:** The number of types was not stated although the description reads as though Hulst may have had only one. However, there is one male type in the collection of the American Museum of Natural History, and there are two labelled as types in the U.S. National Museum. Of the latter, one is labelled "N.Y." (probably incorrectly) and is assumed to be a spurious type. The other is labelled as from Florida and the Hulst collection, and may be a syntype. All three specimens represent the same species as *varadaria*.

*Itame varadaria* is a species with which few lepidopterists have been familiar; it is limited to the Deep South and has not been common in collections. It is known to occur from McClellanville, South Carolina, to southern Florida and along the Gulf Coast to the vicinity of Houston, Texas. It has at least two broods, the spring specimens (March-April) being slightly larger, darker and less brightly marked than summer ones (July-August). Otherwise nothing is known of its life history.

As the species has not been illustrated, I figure a summer brood male (Fig. 1) and spring brood male and female (Figs. 2-3). This female was compared with the holotype of *inaptata* and agrees in almost every detail. *I. varadaria* varies from dull yellowish to grayish brown with a darker brown pattern, and the male has rather wide bipectinate antennae. No very closely related species are known, but the male genitalia of *varadaria* are nevertheless typical of the genus in every respect, being hardly distinguishable from those of the *Itame argillacearia-occiduaria* group. I have examined 34 specimens.

*Aspilates donataria* Walker ("1862"[1863]: 1673), listed in the genus *Itame* as number 4787 by McDunnough (1938: 161), is a *nomen dubium*. It may also be the same as *varadaria* but has never been identified as any known species. The type was reported by Dyar ("1902"[1903]: 315) to be lost, and I am advised by Mr. D. S. Fletcher of the British Museum (Natural History) that it still has not been found. The original description could fit *varadaria* except that the size seems too large. The type locality is Georgia.

I am indebted to Mr. D. S. Fletcher for kindly responding to my inquiries about the Walker types and for lending specimens, and to Drs. C. W. Sabrosky and J. F. G. Clarke for conveying specimens to and from London.

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### TRANSFER OF *CYMORIZA ABROTALIS* WALKER, 1859, FROM *NYMPHULA* SCHRANK TO *DISMILILA* DYAR (PYRALIDAE: NYMPHULINAE, MIDILINAE)

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*Cymoriza abrotalis* Walker (1859: 956) was described from a single male from Rio de Janeiro "in Mr. Fry's collection." Hampson (1897: 140) transferred the species to *Nymphula*, without comment. This placement was followed by Klima (1937: 92).

The holotype of *C. abrotalis* is in the Oxford University Museum. A photograph made by myself in 1958 (Fig. 1) shows clearly that the species is a midiline not a nymphuline, and that it belongs to the genus *Dismidila* Dyar. Although I had seen and photographed the type, I had not noticed the relationship and I omitted the name from my *Revision of the Midilinae* (Munroe, 1970). The maculation and wing shape show that the species is very close to *Dismidila similis* Munroe, type-locality Buenavista, East Bolivia, and to *D. obscura* Munroe, type-locality Petropolis, Rio de Janeiro State, Brazil. In colour it resembles *D. similis* more than *D. obscura*, but it has the hyaline spot of the forewing much larger. In the absence of series and not having compared the types directly I think it better not to establish synonyms. I content myself with transferring the species to *Dismidila* as *Dismidila abrotalis* (Walker), new combination.



Fig. 1. *Cymoriza abrotalis* Walker, holotype, ♂. Oxford University Museum.

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### UNUSUAL COPULATORY BEHAVIOR IN THE NYMPHALIDAE AND SATYRIDAE

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Interspecific, heterosexual coupling among Rhopalocera in the wild is relatively uncommon enough to warrant being recorded in the literature (Hovanitz, 1949; Shigeru, 1956; Stallings et al., 1959; Downey, 1962; Shapiro & Biggs, 1968; Perkins & Gage, 1970; Priestaf, 1970; Platt & Greenfield, 1971). Even more rare are occurrences of intergeneric, heterosexual coupling (Frechin, 1969; Jae, 1972).

To date, however, a search of the literature confirms that instances of neither intraspecific, pleoheterosexual coupling nor intergeneric, homosexual coupling are known. The following account cites examples of each.

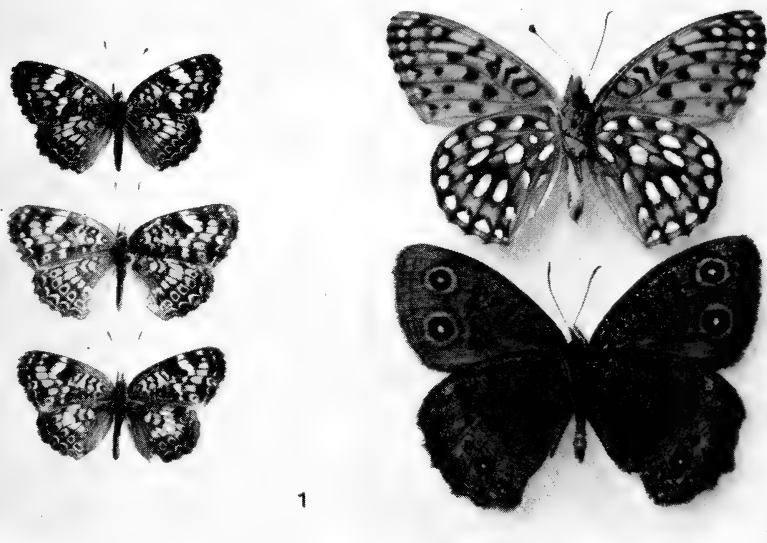
While visiting the Bentsen State Park National Wildlife Refuge, situated thirteen miles northwest of McAllen, Hidalgo County, Texas on 13 November 1962, I came upon a small collateral tributary of the Rio Grande, whose moist sand bar was nearly covered with imbibing butterflies. Bewildered by this spectacle, I cautiously approached and noted several hundred individuals, including examples of *Libytheana bachmanni larvata* Strecker, *Phyciodes phaon* Edwards, *Zerene cessionia* gen. aut. *rosa* McNeill, *Danaus gilippus strigosus* Bates, *Papilio cresphontes* Cramer, *Kricogonia lyside castalia* Fabricius, *Eurema lisa* Boisduval, *Hemiargus ceranus zachaeina* Butler & Druce, *Atlides halesus estesi* Clench, and *Myrcia ethusa* Boisduval.

Of particular interest were three specimens that appeared to be *in copula*. Despite their efforts to escape my net, all three were genitally attached and remained so until placed in a cyanide bottle. Examination of the unlikely threesome revealed 2 ♂♂ and 1 ♀ *P. phaon* (Fig. 1).

Twenty-two months later, on 11 August 1964, a similarly surprising event took place at Camp Sherman, Jefferson County, Oregon. This day, while collecting in the lush meadows that border the Metolius River, I had already taken several copulating pairs of *Speyeria cybele leto* Behr, *S. atlantis dodgei* Gunder, and *S. mormonia erinna* Edwards.

Beside a willow-bordered drainage ditch, I noted a tall blade of grass on which two, *in copula* butterflies were at rest: affixed by their claspers were 1 ♂ *S. m. erinna* and 1 ♂ *Cercyonis pegala ariane* Boisduval. When disturbed, the *S. m. erinna* labored upward—in a forward direction—under the weight of the attached *C. p. ariane*, which it pulled after it. The pair (Fig. 2) was captured in flight at 1400 PDT, placed in a separate cyanide bottle, spread and genitally examined at the same time, and given cross-reference data labels in order to minimize the considerable confusion that already prevailed! All specimens are currently housed in the Allyn Museum of Entomology, Sarasota, Florida.

It is tempting to speculate about the overall importance of these observations regarding the breakdown of behavioral and/or mechanical isolating mechanisms within or between species. Certainly, neither of the two particular unions described could definitively subserve any reproductive end. Behavioral aberrations such as these, and that described by Heitzman (1964), not only challenge the "lock and key" hypothesis, but also suggest the possibility of a parallel development in precopulatory



Figs. 1-2. Specimens taken in copula: (1) *Phyciodes phaon* males and female (center), dorsal surfaces (Bentsen State Park, Hidalgo Co., Texas, 13 November 1962, E. M. Perkins, collector); (2) *Speyeria mormonia erinna* male (above), and *Cercyonis pegala ariane* male (below), ventral surfaces (Camp Sherman, Jefferson Co., Oregon, 11 August 1964, E. M. Perkins, collector).

behavior and/or chemical configuration of pheromones in certain, dissimilar lepidopterous taxa. It is interesting to note that capture time of specimens in the latter event coincides with frequency polygons of observed mating times for both Nymphalidae and Satyridae (Miller & Clench, 1968). Although the significance of both records is subject to debate, if not entirely enigmatic, these data are placed on permanent record in the hope that they might in some way shed additional light on our knowledge regarding insect behavior, pheromones, and/or evolution.

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## NOTES ON THE LIFE CYCLE AND NATURAL HISTORY OF BUTTERFLIES OF EL SALVADOR.

### II. *ANAEA (ZARETIS) ITYS* (NYMPHALIDAE)

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This is the second article of a series dealing with what my sons and I have discovered about the life cycle and natural history of butterflies found in the neighborhood of San Salvador, capital city of El Salvador. The life cycles of many neotropical butterflies are apparently incompletely known, and therefore classification has been solely on the basis of the adult morphological characteristics.

The determination of the species mentioned herein has been done by Dr. Lee D. Miller of the Allyn Museum of Entomology. Adults and at least some specimens of the early stages have been placed in that museum, so as to be available for students of the groups.

In the introduction of our prior article (1973), a rough description of the country, its climatic zones and other pertinent information was given, so as to make an understandable picture of the habitats of the species described in these articles.

*Anaea (Zaretis) itys* Cramer, belonging to the subfamily Charaxinae, has been placed at different times in several genera: *Papilio* (by Cramer, 1777), *Siderone* (by Westwood, 1850), *Zaretis* (Frühstorfer, 1909); and has been described several times, due perhaps to the great geographical, seasonal and individual variation shown. Comstock (1961) uses the name *Anaea (Zaretis) itys*, leaving open the possibility that valid subspecies might be found later.



We had captured a few specimens of this elusive butterfly since 1968, always at around 1000 m, usually while feeding on decaying fruits. But until August 1970 we had never seen the larvae and did not know the foodplant. At that time a larva of medium size, but of unusual shape, was captured on a small tree later identified as *Casearia nitida* (L.). The larva produced an adult male in mid-September. Once the foodplant was known, we made several extensive searches through the different zones of the country where the plant is found, at altitudes ranging from sea level to about 1200 m. Many larvae in different stadia were found and adults were obtained from them. The first time we found eggs was during November 1971, when a female was observed ovipositing on a medium-sized tree in the neighborhood of San Salvador. This female laid about 17 eggs, five of which were collected and put in individual transparent plastic bags. Black-and-white photos were taken of the eggs, and of the larvae at various stages; and measurements and records of developmental time were kept. Head capsules, and larval specimens of each instar were kept in alcohol. The bags in which the process took place were kept at ambient temperature and lighting conditions. Since that time we have been able to obtain eggs at different times of the year and have repeated the process several times with about the same results.

### Life cycle stages

**Egg.** Nearly spherical, about 1 mm diameter, with flattened base and slight depression at micropyle. Color yellowish. Surface smooth (nothing noticeable at 10× magnification). All hatched in 6 days.

**First instar larva.** Head naked, brown, roundish, with slight depressions between epicrania and cervical triangle. Body grayish, naked, wedge-shaped. Changes color and shape after feeding, becoming light brown, and thickening across 2nd abdominal segment. Annulets appear in the segments. Grows from 2.5 mm to 5.2 mm in 7 days.

**Second instar larva.** Head and body dull dark brown. Short and thick horns on the apex of epicrania. Anal segments with short and flattened "tails." Spiracula of lighter shade than body. Spiraculum on 2nd abdominal segment located much higher than the rest, and the one on the 8th abdominal segment slightly out of line with the preceding ones also. Larvae grow from 9.5 mm–1.1 cm in 6 days.

**Third instar larva.** Head dark gray with black, blunt, thick and short horns on epicrania. Tiny graining apparent on head surface. Body dark grayish brown, with lateral light ridge starting at first thoracic segment running to first abdominal segment supraspiracularly. Another light brown ridge originating high on second abdominal segment under a lateral pyramidal projection located in the subdorsal area, going through remaining abdominal segments, supraspiracularly, ending at side of the short anal tail. Lateral projections on the second abdominal segment united postero-dorsally by thick and dark brown ridge bordered by clear margin, and each one terminated by a scolum with minute spines. Spiraculum immediately below the projected scolum, completely out of line with rest of spiracula. 3rd and 4th abdominal segments each crossed dorsally by a clear brown line, parallel to the clear margin on 2nd abdominal segment. A large rhomboid of light brown color covering the dorsal area of the 5th, 6th and 7th abdominal segments and partly

the 8th. A scattering of tiny spines all over the body. Larvae grow to from 1.6–2.0 cm in 8 days.

**Fourth instar larva.** Same general shape and coloration as third instar, but has developed some spines on epicranium, below the horns and at sides of them. Whitish graining on thoracic segments. Light rhomboid on last abdominal segments bordered now by black triangles, and many minute spines noticeable on these segments. Larvae grow to from 2.3–3.1 cm in 9–11 days.

**Fifth instar larva.** Lighter color than 4th instar, hump at 2nd abdominal segment very exaggerated. Dorsal area of abdominal segments with lighter brown rhomboid markings. Spines more noticeable now, mostly at lateral zones of last abdominal segments. Spines now prominent at sides of head and at base of and between epicranial horns. Some of these spines have a white tip. Tails look very flattened and united at the base. Larvae grow to from 4.3–5 cm in 11–19 days.

**Pre-pupa.** Considerably shorter and thicker than 5th stadium and of lighter color. Spines incurvated laterally with anal prolegs affixed to silken mat for one day.

**Pupa.** Can be light green or light brown. Cremaster very elaborated and reddish-brown. Abdominal segments tapering abruptly from wing case to cremaster, and thoracic segments gradually to slightly bifid head. Yellowish ridge dorsally separating tapering abdominal segments from the rest, and from border of wing cases. Spiracula inconspicuous light brown. Measurements vary from 1.5–1.9 cm long, 1.0–1.2 cm laterally at widest point and 0.9 to 1.1 cm dorsoventrally at widest point. Duration 8–10 days.

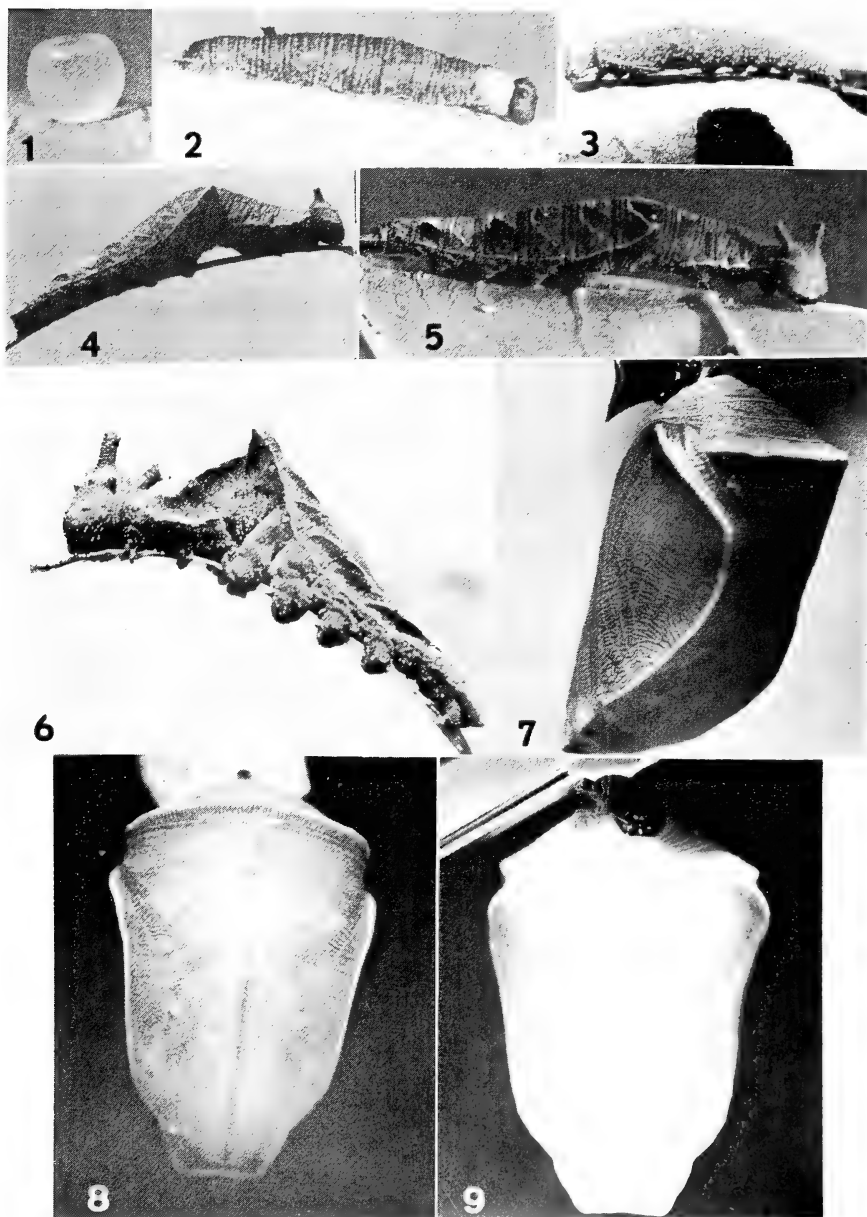
**Adults.** Adults show a marked sexual dimorphism, and minor individual differences between specimens of the same sex. *Males.* Both fore and hindwing orange dorsally, with darker apical markings on forewing, and darker submarginal broken line on hind wing, with small black dots in variable number between the dark line and outer margin. Apex more or less acute, outer margin undulate, more or less convex above tornus and inner margin more or less concave at side of tornus. Usually with two transparent roundish "windows" located on cells M3 and Cu 1, near discal cell, but lacking in some individuals. Hindwing with a humeral lobe and emargination at inner angle. Outer margin of hindwing concave, more or less sinuose, with blunt and projected anal angle, and anal lobe.

Ventrally both wings brownish orange with darker line that goes from anal angle to mid-costal area on hindwing, continuing from mid-inner margin to apex on forewing. This line imitates the central vein of a leaf, and there are besides faint shadings imitating secondary veins, mostly on hindwings. *Females.* Shape of wings as in male, with apex generally more acute. Forewing dorsally, light yellow with brown markings at apex. Hindwing with orange shading, more pronounced at anal angle. Both wings ventrally dirty yellow with brown markings imitating, as in male, the venation of a leaf. "Windows" usually present on forewing, but may be lacking.

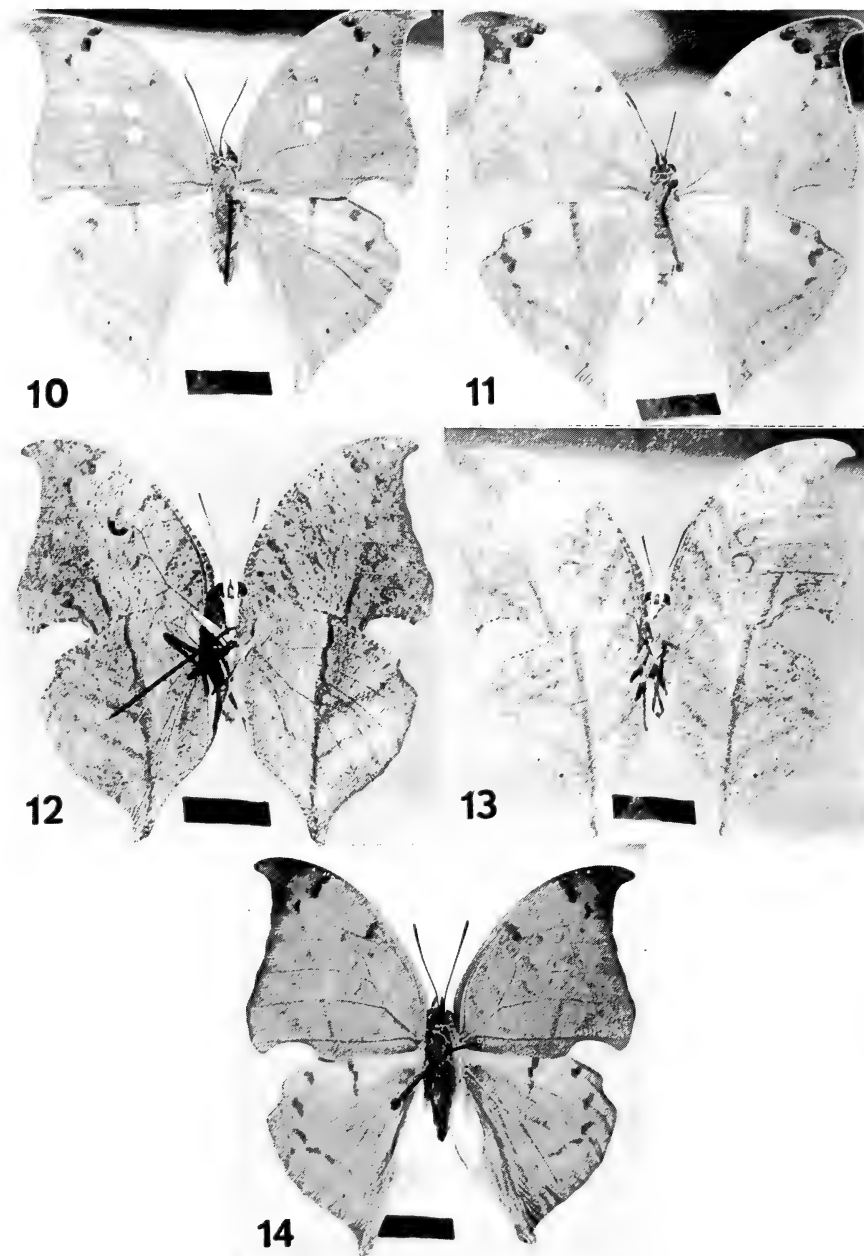
In both sexes body same color as dorsal wings. Palpi, eyes and proboscis, brown. Antennae orange. Individual differences have been noticed on specimens emerging during the same month. Size of individuals of the same sex is variable; in general females are larger than males. Average measurement is 4.2 cm for males and 5.3 cm for females (tip-to-tip of spread forewings). Total development time, under laboratory conditions, ranges from 56–68 days, females usually taking more time than males.

### Natural History

We have found eggs and larvae of *A. (Z.) itys* on only one species of the Flacourtiaceae family (also known as Samydaceae): *Casearia nitida* (L.) Jacq. This plant grows to become a small tree about 5 m high and is fairly abundant from sea level to 1200 m of altitude, in heavily disturbed second-growth plant communities, usually along ravines or



Figs. 1-9. *Anaea (Zaretis) itys* Cramer: (1) egg, about 1 mm; (2) first instar larvae ready to moult, about 5 mm; (3) second instar larva, about 1 cm; (4) third instar larva, about 1.8 cm; (5) fourth instar larva, about 3 cm; (6) fifth instar larva, about 4.5 cm; (7, 8, 9) pupa, lateral, dorsal and ventral view,  $1.5 \times 0.9 \times 1$  cm.



Figs. 10-14. *Anaea (Zaretis) itys* Cramer: (10) adult male with "windows," dorsal view; (11) adult female with "windows," dorsal view; (12) adult male without "windows," ventral view; (13) adult female with "windows," ventral view. (14) adult male without "windows," dorsal view. The black bars measure 1 cm.

unused land. The plant sheds all of its leaves prior to the rainy season, during March or April. When bare of leaves, the plant flowers, and some time later starts to grow the new leaves. By July–August the coffee-like fruits are green and become yellowish-orange by October. The leaves of this species are attacked by a disease that curls the edges and turns the rolled portion dark brown and dries it.

Recently-emerged larvae of *A. (Zaretis) itys*, like all the larvae of Charaxinae we have observed, completely eat the egg shell, and stay under the leaf for a full day without further eating. They then move to the edge of the leaf, usually to the tip, eat around a vein until it is bare and prolong it with excreta affixed with silk. This formation is used as a resting place through the first, second and third stadia, the larvae usually keeping the head pointing outwards. During the fourth stadium the larvae leave this resting place and wander about the plant. While not feeding they stay motionless at the edge of a leaf imitating to perfection a dried portion of it. This behavior is kept also through the fifth stadium. When ready to pupate the larva shortens and weaves a silken mat under a leaf or on a twig with many leaves and affixes the anal prolegs to it. Then the prepupal larva positions itself in the peculiar fashion of the genus *Anaea*, incurvated sideways, not hanging.

The pupae of *Anaea (Z.) itys*, like some other *Anaea* spp. can be either light green or light brown, regardless of environment, and their shape is very similar to *A. (Consul) fabius* Cramer and *A. (Memphis) eurypyle confusa* Hall, (MSS in prep.), being quite hard to tell from these. The pupae are rather rigid and will only occasionally react when handled with short lateral movements.

The adult of *A. (Z.) itys*, like most Charaxinae, are swift fliers, what makes them hard to see in the field unless they are feeding, which they do on fermented fruits and from open cavities of tree trunks. The females when ready to oviposit, fly rapidly around the foodplant and alight on a group of mature leaves. Sitting under one of them, they deposit one egg on the underside and immediately resume their flying. They repeat this action about five times before taking a rest on a neighboring tree for some ten minutes, and then go back to flying around the foodplant, depositing some more eggs, until a total of about 30 are deposited before the female flies away. Both sexes often sit on tree trunks, head pointing downwards. Males chase other butterflies that cross their territory. We have observed males attacking falling leaves.

#### DISCUSSION

According to Comstock (1961), there is at least some information about the life cycle of *Anaea (Zaretis) itys* in the works of Sepp (1828)

and Müller (1886) but apparently this is the first complete life cycle description with photographs.

The eggs of this species are very similar to the eggs of *Anaea* (*Consul*) *fabi*us, *A. (C.) electra* Westwood, *A. (Memphis) eurypyle confusa* and *A. (M.) pithyusa* R. Felder, except for the yellowish, rather than greenish, color, as in the bigger egg of *A. (Siderone) marthesia* Cramer. First instar larvae are very similar also to the larvae of the species mentioned, except for color. From second stadium on, they resemble more the larvae of *Prepona* spp. in shape and behavior, even though the *Anaea* spp. mentioned have similar habits up to the third instar. The pupae again are very much like the pupae of *A. (C.) fabius*, *A. (C.) electra* and *A. (M.) eurypyle confusa*, even in the characteristic of being at times light brown and at times light green. We thought at first that this duality of coloration was caused by "environmental conditions during pupation" as Harrison (1963) assumed for the same phenomenon in *Opsiphanes tamarinidi* Felder (Brassolidae). But on several occasions groups of larvae of *A. (Z.) itys*, *A. (C.) fabius*, *A. (M.) e. confusa* and even *Opsiphanes tamarinidi* and *O. cassina fabricii* Bdv. kept under similar conditions all through their developmental stages have produced simultaneously and indiscriminately green and brown pupae, invalidating this explanation. The duality of coloration in the pupae of these species is not dependent on the sex of the individuals either: we have had males and females come out of brown and green pupae. Whether or not this phenomenon is hereditary, we have not yet been able to find out.

The close affinity between the genus *Prepona* and the genus *Anaea* is evident: apparently this species, *A. (Zaretis) itys*, is intermediate between *Prepona* and "typical" *Anaea*. As is the case in *Prepona* spp., the spiraculum on the second abdominal segment of *A. (Z.) itys* larvae is located very high on the subdorsal area, being not so high in the other *Anaea* spp. Yet the spiraculum on the eighth abdominal segment is slightly higher in the three cases.

The larvae of *A. (Z.) itys* are very slow moving and apparently have no chemical or mechanical defenses, relying solely on mimicry for protection against predation, as in *Prepona* spp. During the initial three instars *Prepona* spp., *A. (Zaretis) itys*, and the other species of *Anaea* we have studied use the same strategy: the bared vein prolonged with frass that they use for resting, imitating to perfection dried portions of leaf tissue still attached to the vein. But from the fourth instar on the larvae of *A. (Z.) itys* behave more like *Prepona* larvae, staying motionless usually on the edge of a diseased leaf, mimicking its curled and dried edge. Moving about for feeding purposes is usually done at dawn or

dusk, minimizing the chances of diurnal bird predation. The pupae, green or brown, are very hard to spot among the foliage. The adults, besides their rapid and vigorous flight, mimic decaying leaves when at rest giving them a near perfect concealment among vegetation.

The mimicry exhibited, while reducing predation, does not protect from parasitism caused by Tachinidae of the kind that deposit the eggs on the surface of the leaves where the larvae are feeding. Quite often we have collected larvae that have been killed during the last larval stage or shortly after pupation by tachinid larvae, not yet determined. The larvae of *A. (Z.) itys* are also very prone to a disease that softens their bodies, making them burst and die.

As in the case of *Prepona o. octavia* (Muyshondt, 1973), a possible cause of massive larval mortality is the characteristic of the foodplant, *Casearia nitida*, of shedding all the leaves in a short period of time, just prior to the rainy season, (late March and April). The shrubs or small trees then remain bare of leaves for a period of two to three weeks.

It is possible that the larvae of *A. (Z.) itys* feed on other related species of the Flacourtiaceae family, as is the case with *A. (Siderone) marthesia*, although we have not found evidence to support this.

Under laboratory conditions, this species took an average of 62 days to complete development from egg to adult. Therefore there could be some six generations a year. Since the species is not common, we suggest that the females of *A. (Z.) itys* are not particularly prolific and that parasites kill many larvae. This suggestion seems to be supported by the fact that adults of *A. (Zaretis) itys* are mostly found during the dry season, and, "during the dry season the population of small insects," (including parasites), "is distinctly reduced seemingly by desiccation associated with small body size" (Janzen and Schoener, 1968). In addition to the paucity of parasites during the dry season, their efficiency in laying eggs on the leaves might be affected by the heavy dust layer deposited by the seasonal northern winds.

#### ACKNOWLEDGMENTS

We are grateful for the valuable assistance of Stephen R. Steinhauser, who besides sharing his own observations on the adult behavior of this species, gave us free access to his technical library. We are particularly indebted to Dr. Lee D. Miller who identified the specimens and to Dr. T. D. Sargent who made invaluable criticisms and suggestions regarding the manuscript. Specimens of early stages and adults have been placed in the Allyn Museum of Entomology, Sarasota, Florida.

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SOME OBSERVATIONS ON *DRYAS IULIA IULIA* (HELICONIIDAE)

*Dryas iulia iulia* (Fabricius) is a common species in El Salvador and is found flying in wide open territory or under low vegetation from sea level to about 2000 m. Both sexes are assiduous visitors of flowers. The females lay eggs individually (pers. obs.) on tender terminals of various species of wild Passifloraceae vines.

My sons and I have reared *D. i. iulia* many times from egg to adulthood, the process taking about one month. We have not found any case of parasitism yet.

Males are bright orange dorsally, while the females are a dull orange dorsally. Both sexes have black margins on both wings and a black subapical band. When handled, males extrude a double gland under the genitalia, and females a semicircular one above the genitalia. Due to the interference of these glands, we have been unable to obtain hand pairing with this species. Both sexes produce a punget scent when disturbed.

Many times we have witnessed nuptial flights, and always the male has been the active flyer, the female hanging limp. On 14 August 1971, shortly before noon, a pair consisting of a fresh male and an old and damaged female was observed in copula on a low shrub. When disturbed with the handle of a net, the male took flight with the female hanging motionless. They alighted some 20 m away in low vegetation. Three times we forced the pair to move, and everytime the same thing happened. The pair was then netted and brought home, still in copula, in a plastic bag. Next day, the female was put in the bag on a *Passiflora* sp. vine and was left there until the morning of the 17th, when it was killed and dissected. It had laid 37 eggs on the vine, and no eggs were found in the abdomen.

On 5 October 1972, another pair was observed copulating. This time both the male and female were recently emerged. They were found at 0920 on the vine where they had been reared. While being observed from some distance, the male took flight, carrying the passive female, and alighted some 10 m away at 6 m above the ground on a white wall, where the pair was very conspicuous. They stayed motionless, male above, for one hour, until forced to fly into a wire cage. They then stayed on the side of the cage, male above, without further movement until copulation was ended at 1455. At that time both butterflies started flying in the cage trying to escape. Again, the female was put in a plastic bag on the vine for two



days. Then it was killed and dissected. One egg had been deposited on the vine, and four were found in the abdomen.

The vertically oriented eggs are yellow, about 1.5 mm long by 1 mm wide, covered by a reddish coating, and with ribs and sculpturings somewhat resembling Danaidae eggs. They hatch in four days. First instar larvae, about 2 mm long, are yellowish, head and body. At this stage the head shows no markings or spines, but has some scarce fine setae. The body has no markings or spines either, but each segment has a transverse row of fine, dark setae. From the second instar, on the head shows white and reddish markings and two spines, one on each epicranium. The body is covered by rows of spines and shows white and reddish markings, such as described in great detail by Richard (1968, J. Lepid. Soc. 22: 75-76) for *Dryas iulia delia* (Fabricius).

The larva of *D. i. iulia*, upon emerging from the egg, eats the egg-shell, at least partially, and then moves to the edge of the leaf where it starts feeding. It leaves small hanging sections of the leaf that soon wilt and dry, forming an excellent camouflage. The first, second and sometimes third instar larvae are easily located by examining the leaves that show these ragged edges. Larger larvae move about the vine and can cause a mild rash on the skin when touched with the back of the hand.

It is interesting to note that in the two cases of copulation we are reporting, the young female laid only one egg and had four in the abdomen, whereas the old and damaged female laid 37 eggs and had none left in the abdomen. The females probably copulate several times during their life span and lay considerably more than 30 eggs, contrary to Labine's suggestion (1968, in Young 1972, Acta Biol. Venez. 8: 1-7) that most species of Heliconiinae probably lay less than 30 eggs during the average females lifetime. Another species that tends to contradict Labine's suggestion is *Dione iuno huascama* Reakirt, whose female often lays groups of over 100 eggs during a single sitting (pers. obs.). This is the only heliconiid with gregarious habits all through its developmental stages that we have found in El Salvador.

As seen in the description above, in *D. iulia iulia* the male is the active flying partner. In most of the reports on butterfly copulation we have found, (Pronin 1964, J. Lepid. Soc. 18: 35-41; Ferris 1969, J. Lepid. Soc. 23: 271-272; Carcason 1970, J. Lepid. Soc. 24: 72; Jae 1972, J. Lepid. Soc. 26: 28; Priestaf 1972, J. Lepid. Soc. 26: 104), the active partner usually has been the female.

A final comment: the description by Richard (1968, op. cit.) of the early stages of *Dryas i. delia* matches exactly the early stages of *Dryas i. iulia*, except for the first instar and the fact that we have always found five larval stages instead of four. We suspect that the larvae he collected and thought were first instar were actually second instar larvae.

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#### NEW MEXICAN SPHINGIDAE RECORDS

Since Hoffmann's catalogue of Mexican sphingids (1942, An. Inst. Biol. Univ. Nal. Autón. México 13: 213-256), few species have been added. Some of them like *Phryxus caicus* Cram. and *Callionima nomius* Wlk. were recorded in 1967 (Beutelspacher & Vázquez 1967, An. Inst. Biol. Univ. Nal. Autón. México 38, Ser. Zool. (1): 75-77). Hoffmann's catalogue, however, requires numerous generic changes which we will be making soon, based on Hodges (in Dominick et al., 1971, Moths of America North of Mexico, fasc. 21, Sphingoidea).

Thanks to Mr. Roberto de la Maza and his sons, we are learning of more new species for Mexico, and at this time can add two new genera; one of Neotropical, and the other of Palearctic origin.

*Amphimoea* R. & J. *A. walkeri* Bdv. (= *staudingeri* Drc., *magnificus* Rothsch.)

*Amphimoea* is a monotypic genus and the species *A. walkeri*, according to Druce (in Godman & Salvin, 1886, *Biologia Centrali-Americana*, Insecta, Lepidoptera Heterocera 2: 311; 3: pl. 65-4) and Draudt (in Seitz, *Gross-Schmetterlinge der Erde*, VI, Heter. Amer.: 847, 865), is distributed from Chontales, Nicaragua, Chiriqui Volcano, Panama to south of Brasil. These authors mention that the caterpillar feeds on a *Jatropha* species.

One female specimen from Dos Amates, Catemaco, Veracruz, taken in August 1965, is in the De la Maza collection. In Hoffmann's catalogue, this genus must be situated before *Manduca* Hbn.

*Cressonia* Grt. & Rob. *C. juglandis* (J. E. Smith) (*Sphinx juglandis* J. E. Smith)

This genus of Palearctic origin, previously known only from the United States, is recorded now for the first time in Mexico. According to Hodges (op. cit.), "the larvae feed on various species of hickory (*Carya* species) and walnut or butternut (*Juglans* species), and perhaps beech (*Fagus* species)."

The following specimens are in the De la Maza collection: one male from Parque Funeral Guadalupe, Monterrey, Nuevo León, 17 June 1970; one male and one female from El Barrial, Monterrey, Nuevo León, 10 September 1971. In Hoffmann's catalogue, this genus must be situated after *Paonias* Hbn.

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#### APODEMIA MORMO NEAR DIALEUCA (RIODINIDAE) FROM MONTANE SOUTHERN CALIFORNIA: NEW FOR U.S.A.

Eleven male and 23 female unusual-appearing *Apodemia mormo* (Felder and Felder) were taken on 3 and 5 June 1966 by John Justice, Keith Hughes and the writer on Sugarloaf Ridge, north of Barton Flats, San Bernardino Mountains and County, California. They were closely associated with the prostrate buckwheat, *Eriogonum wrightii subscaposum* Wats. (Polygonaceae), growing on gravelly slopes above 2600 m elevation in open mixed deciduous-coniferous forest dominated by ponderosa pine, mountain mahogany and manzanita. The entire series was shown to Dr. Jerry Powell, who found them nearly identical to *A. m. dialeuca* Opler & Powell, described from similar habitats in the Sierra San Pedro Martir of Baja California, Mexico, nearly 500 km south of Barton Flats (Opler & Powell 1961, J. Lepid. Soc. 15: 145-171; Patterson & Powell 1959, J. Lepid. Soc. 13: 229-235). The wings dorsally have large white spots on a dark gray background with little if any red or orange suffusion, lending a distinctly tessellated appearance to the insect; the ventral surfaces are dusted generously with light gray scales, especially on the outer one-third of the primaries and outer two-thirds of the secondaries (Fig. 1).

Subsequently other collectors have taken examples of this phenotype at the same and nearby localities, including some in September and early October suggesting multivoltinism (Opler, *in litt*). It is rather peculiar that this interesting population remained undiscovered until recent years. The fact that collectors like the Sperrys, Rindge, Comstock, Martin and others failed to turn it up in many years of intensive collecting during the last half-century causes one to wonder if it might be a very recent segregate from *A. m. virgulti* Behr populations to the south and west, or from *A. m. near mormo* and "blend-zone" populations to the east, north and northwest at lower elevations. The nearly exact similarity in facies, habitat and probable host-plant of this new population and topotypical *dialeuca* suggests either a common phenotypic response to similar environmental conditions, or previous ecologic and



Fig. 1. Male (upper left dorsal, and upper right ventral, surfaces of same specimen) and female (lower left dorsal, and lower right ventral, surfaces of same specimen) *Apodemia mormo* near *daleuca* Opler & Powell, Sugarloaf Ridge 8500' (2600 m), San Bernardino Mountains, San Bernardino County, California, 5 June 1958, leg R E Stanford.

genetic continuity between the presently disjunct populations. Future studies will be necessary to clarify the taxonomic status of this new population, its geographical distribution and relationship to contiguous elements of the *mormo* complex. For the present, *Apodemia mormo* near *daleuca* can be added to the butterfly fauna of California and the United States. (Thanks to Keith Hughes, Paul Opler and Jerry Powell for assistance in preparing this note, and to Louis Brunelle of Fort Dix, New Jersey for the illustration.)

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#### *BOLORIA SELENE* (NYMPHALIDAE) AMBUSHED BY A TRUE BUG (HETEROPTERA)

Predator-prey relationships between butterflies and other insects have been infrequently noted in the literature. An instance of a robber fly eating *Papilio eurymedon* Lucas is known to me (correspondence with T. Rogers) and dragonflies have been seen to capture and consume butterflies. But the following account is the first observation of which I am aware of a true bug preying upon a butterfly.

On 20 August 1970, I visited the Moxee Bog Reserve in Yakima County, Washington. This site, protected by The Nature Conservancy through the efforts of

Society member David McCorkle, nurtures one of the few known colonies of *Boloria selene* Denis and Schiffmueller in the state. The habitat here is an anomaly—a quaking bog in sagebrush desert. Both the bog and the insect seem to be glacially relict features. Various boggy pockets in the Columbia River Basin serve as refugia for formerly widespread species of plants and animals. These species were largely wiped out by regional flooding of the basaltic coulee country which happened following melting of the Pleistocene ice dams on Glacial Lake Missoula.

I was aware of the historic enigma of Moxee and was visiting it as a general exercise in nature perception. My specific objective was to photograph *selene* and to observe its behavior for a work on Washington butterflies. I first encountered the insect along the ecotone where cattail marsh and sedge bog meet a drier, alkaline bench dominated by a native iris. Throughout the afternoon, *selene* was uncommon and perched infrequently after long, sustained and fairly strong flights. As sunset approached, the butterflies became suddenly very abundant (or rather, much more in evidence). Scores of fresh individuals of both sexes were now on the wing deeper into the wettest parts of the bog. Flights grew shorter and slower, perching occurred more frequently. Many of the Silver-bordered Fritillaries clung to grass blades, while others fed on five species of flowers: A *Verbena*, Rabbitbrush (*Chrysothamnus nauseosus*), two yellow daisies and a mint (*Mentha*). *Coenonympha tullia* was also abundant, but I observed no encounters between the two species of butterflies. Mating activity became intense during the last half hour of direct sunlight. Many pairs of *selene* were observed courting and copulating, the latter accomplished *in situ* and never in flight. Immediate precopulatory behavior consisted of a gentle, slow fluttering of the wings as the two partners orbited one another by crawling around the grass blades to which they both clung.

At about 1800 (PDT) I noticed an individual of *selene* in an unusual position. A fresh female, it was wedged upside down between two flower heads of Rabbitbrush, with its wings spread open as if mounted. Thinking at first it was simply a strange feeding posture, I set about exploiting the excellent photographic opportunity thus afforded. Soon I noticed that the butterfly moved only feebly and indeed appeared to be immobilized. Looking closely, I was astonished to see several true bugs clustered on the same flower heads that bore the butterfly. Three of the heteropterans were visible, and two were in contact with the butterfly at the time. Their refined camouflage (yellow, mottled with black) accounted for my initial failure to see them against the Rabbitbrush florets. As I watched, the bugs clambered over the butterfly, presumably imbibing its fluids with their probosci, which often came into contact with the hapless *selene*. A small yellow crab spider occupied the same flower head, but did not appear to be implicated in the entomophagy. I collected the butterfly (which soon died) and one of the suspected assassins. When the *selene* became desiccated, its abdomen clearly showed a small hole in its side where it had been pierced.

The bug turned out to be a member of the family Phymatidae, probably of the genus *Phymata* Latreille. These bugs are known, most aptly, as Ambush Bugs. W. S. Blatchley (The Heteroptera of Eastern North America, Indianapolis, 1926) wrote this account of Ambush Bugs and their tactics: "Only about 80 species of the family are known, 14 from North America. They are all predacious in habit, hiding themselves in the heads of flowers, especially Compositae, where they await the coming of bees and other nectar-seeking insects. When the prey is within reach the bug makes a quick stroke with its sabre-like fore tibiae, draws the victim within reach of its beak and then leisurely sucks it dry.' The behavior of my predator obviously matched the family characteristics, and the means of actual capture, which had baffled me, is explained. Surely the Ambush Bug deserves its name if it can sieze and overpower an insect so relatively large, strong and fleet as a Silver-bordered Fritillary. However, one bite from a *Phymata*, quickly executed and well placed, might well disable an even larger prey than *selene*. I know. As I was

returning to my car after this hot, damp adventure in Moxee Bog, I felt an excruciating pain in my foot. Cursing, I tore off my boot and found the vector of my intense discomfiture: an Ambush Bug. I had shared *selene's* fate, and came out only slightly better: my foot swelled and throbbed for hours afterward.

Was there ethological significance to the prey-positioning? Do heteropterans usually prey communally when butterflies are the target? I would be most interested in reactions to these questions, and in reports of insect predation on butterflies in general. Thanks be to Dr. Dennis Paulson of the Department of Zoology, University of Washington, and to the library staff of the Royal Entomological Society of London, for aid in identifying the Ambush Bug.

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### BOOK REVIEW

SOUTH'S BRITISH BUTTERFLIES, by T. G. Howarth, illustrated by A. D. A. Russwurm and R. B. Davis. 1973. xiii + 210 p., 48 colour plates, 26 drawings, 57 maps. Cased. Frederick Warne & Co. Ltd., London and New York. Price £10.50 UK.

PROVISIONAL ATLAS OF THE INSECTS OF THE BRITISH ISLES: PART 1 LEPIDOPTERA RHOPALOCERA, BUTTERFLIES, edited by John Heath. 1970. iii p., 57 maps. Natural Environment Research Council. Agent: E. W. Classey Ltd., Middlesex, England. Price 50 p. UK.

PROVISIONAL ATLAS OF THE INSECTS OF THE BRITISH ISLES: PART 2 LEPIDOPTERA (MOTHS—PART ONE). LASIOCAMPIDAE: SATURNIDAE: ENDROMIDAE: DREPANIDAE: THYATIRIDAE: SPHINGIDAE: NOTODONTIDAE: LYMANTRIIDAE: ARCTIIDAE: NOLIDAE, edited by John Heath and Michael J. Skelton. 1973. iii + 3 p., 102 maps. Natural Environment Research Council. Agent: E. W. Classey Ltd., Middlesex, England. Price £1.00 UK.

The butterflies of Britain must be the most intensely studied butterfly fauna in the world. The tradition of butterfly collecting is probably stronger there than anywhere else, extending back to the parson-naturalists and other curious people in the eighteenth century, who have had to deal with a fauna of only 61 resident species (fewer than Long Island, and five of them now extinct), 3 regular migrants and a total of 41 assisted and unassisted strays and immigrants. This great band of bug-hunters has successfully recorded the distribution of the butterflies of most of England, about half of Scotland and scattered areas of Ireland; compiled by computer these records provide intensive distribution maps of all 56 residents, plotted on a 10 kilometre grid covering the whole area. Intended as the basis for conservation of dwindling species (they clearly show the decline of many, and the apparent extinction of one moth), these maps, now published provisionally for the butterflies and many of the more spectacular moths, are a triumphant combination of amateur natural history with professional data-processing; they will be of particular interest to the zoogeographer, and invaluable to the collector, observer or photographer, who with the aid of British Ordnance Survey maps or the *AA Book of the Road*, all bearing the same reference grid, can now pinpoint his quarry to within 100 square kilometres. Discreet enquiries with the Nature Conservancy can often produce the exact spot for the really localised species.

The butterfly maps re-appear, considerably improved by new records for the common or secretive species, and for the less scenic parts of the North and Scotland,

in the magnificent re-written version of Richard South's *The Butterflies of the British Isles*. For more than half a century this knapsack-sized, charming but slightly rambling guide has remained the standard work, while many other books, bigger and smaller, came and went. The book now re-emerges as a properly arranged, large-format, popular monograph, the text for each species divided by sub-headings for easy reference, with a fine set of illustrations of the butterflies by A. D. A. Russwurm, and of the eggs, final instar larvae (including a highly magnified seventh segment) and pupae, copied by R. B. Davis chiefly from original paintings by F. W. Frohawk; it is a pleasure to report that the printing of the beautiful Frohawk drawings is far better than in their first production in the two-volume limited edition of Frohawk's *Natural History of British Butterflies* in 1924.

There is no doubt that this will continue as the standard work on the subject, combining as it does the outstanding features of two earlier works with the latest information on the biology of the British species, and showing the influence of new attitudes to lepidopterology which were pointed by E. B. Ford's seminal book *Butterflies*. Some of South's original text from the more leisured world of 1906 is retained. To say of the Small Copper's habit of flying at other butterflies, "Whether these seeming attacks are really due to pugnacity . . . or are merely of a sportive character, is not altogether clear; when the meeting is between two Small Coppers it usually results in a series of aerial evolutions by the pair, so it would seem that there is a good deal of playfulness in the business," sounds strange today (though couched in the jargon of the behavioural sciences it would be little more informative), but it makes pleasant reading. The short section on the history of each species, usually detailing the first discovery of the butterfly in Britain, and including a record of the Painted Lady from 1272, is also great fun. (I have a poser here for lepidopterists: what is the earliest, recognisable picture of a butterfly species? Any advance on the Meadow Brown and Small Tortoiseshell in *The Garden of Delights* by Bosch, ca 1503?)

British collectors, with their small fauna and accessible countryside, have lacked the lure of native rarities (although it is surprising what they missed in Scotland and Ireland), and have tended, like the not so wealthy stamp collector unable to afford the great prizes of philately, to go for "printing errors." The space devoted to these, with their Latin names, is a thought overgenerous (though it will please a good many collectors), but it is good that considerable attention is now given to geographical variation as well. The amateur lepidopterist could well move with the times and become, in the real sense of the word, more conscious of ecology; there are signs that the distribution map scheme is providing a welcome stimulus by making the collection of data for those 3600 grid squares at least as challenging as hunting for mutants. I hope that by the time the next successful edition appears, it will be possible to compile more information on such things as habitat preferences and limits of distribution; there is for instance the marked coastal distribution of the Grayling, which few would have guessed at, and which goes unremarked in the text. I believe that the literature is extensively misleading on some species. Is it true that the Ringlet is a shade butterfly? And then every book I have seen states that the Green-veined White does not occur in cultivated land. Now while it is true that a *Pieris* in a wild place, particularly in Scotland where the other two species are comparatively rare, is overwhelmingly likely to be Green-veined, the reverse is not true: this species was common and co-existed with the others in the gardens and parks of suburban Liverpool when I was a boy. The impossibility of separating British *Pieris* on the wing may have allowed this error to go unchallenged. There is still much to be done on the distributions and voltinism of the two (or one-and-a-half) species of British *Aricia*.

My only qualm about this lovely new book is for the plight of the beginner and the schoolboy, who need a little more help with identifications which are child's play to Graham Howarth; how does one distinguish the various female Blues and Hair-

streaks at a glance, and for the rank beginner or general naturalist, what distinguishes the Grizzled and Dingy Skippers? Confusion of these last resulted in several incorrect records, now expunged, in the *Provisional Atlas*. The schoolboy (or school-girl, if she is liberated enough to enter this male preserve) might well forego this book till his pockets are larger, and find a second-hand copy of *A Butterfly Book for the Pocket* by Sandars, which despite its amateur illustrations and frankly surrealist distribution maps, did come close to the Peterson identification system. For the visiting American collector, who will already be familiar with some of the species, the choice is between the Houghton-Mifflin *Field Guide* to the European butterflies, and this new work. Outside Britain, one must have the more extensive *Guide*, but "South" will give him far better service on a stay in Britain, for he will not be repeatedly tracking down his specimen to something found only in the Balkans (though in "South" beware the pictures of spectacular rare aberrations). And then there are those detailed maps, which could nearly double one's number of species. Irish and Scottish Americans visiting their homelands should get a set of distribution report cards from the Nature Conservancy as well; the data are badly needed!

And of course, if you have a library of standard works on the world's butterflies, add this one. It is worth every decimalised penny.

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AN INDEX TO THE DESCRIBED LIFE HISTORIES, EARLY STAGES AND HOSTS OF THE MACROLEPIDOPTERA OF THE CONTINENTAL UNITED STATES AND CANADA, by HARRISON M. Tietz, 1972. v + 1041 p. in 2 volumes, cloth bound. Allyn Museum of Entomology, Sarasota, Florida. \$25.00. Distributed by Entomological Reprint Specialists, P.O. Box 77971, Dockweiler Station, Los Angeles, California 90007.

This large work of compilation by Harrison Morton Tietz (1895–1963) was intended to provide references to all published information on the early stages of macrolepidoptera for America north of Mexico, being the only index of this nature to appear since Henry Edwards' "Bibliographic Catalogue of the Described Transformations of North American Lepidoptera" (1889, Bull. U.S. Natl. Mus. 35.). Its coverage appears to be reasonably thorough to about 1950, when the author left off his search of the literature to prepare the manuscript. Negotiation with the Smithsonian Institution to publish the work continued for a time thereafter, but final arrangements concerning changes in format, etc., were never completed. The text as now issued is just as it was left by Tietz, although retyped. With the exception of a 2-page introduction by William D. Field and J. F. Gates Clarke, which has the appearance of letterpress printing, the text was reproduced from typed copy by photo offset. The 2 volumes have good quality buckram bindings which in themselves are worth a large part of the purchase price.

The work is divided into two major parts (which do not coincide with the bound volumes). Part 1 contains a list of entomological publications consulted (23 p.), a list of common names of Lepidoptera (33 p.), and the most important section, the list of references to published life history information, indexed alphabetically by species with hosts listed for each (636 p.). Part 2 contains an index of common and scientific names of food plants listed by common names (101 p.), and an index of hosts listed mainly by scientific names, each with a listing of all the species of macrolepidoptera reported to feed on it (221 p.). The work ends with a 12-page list of changes in nomenclature for plant names, giving the old name and the corrected equivalent used in the host index of part 2.

The nomenclature follows rigidly that of the McDunnough check list of 1938, and no effort was made to correct names or revise the manuscript in any way. Admittedly, the up-dating of so large a work would have been a demanding and thankless task for anyone not credited with authorship and would have further

delayed publication, perhaps indefinitely. The Lepidoptera species index includes synonyms and subspecies names, under each of which the reader is referred to the applicable species name. Inclusion of all such names seems unnecessary or even confusing, because life history information was only occasionally published under the synonymic name, and references cited may or may not apply to the subspecies listed.

Sometimes the bibliographic references under a species name are missing; e.g., for *Apaeecasia atropunctata* (p. 123), *Eupithecia bradorata* (p. 145), *Septis castanea* (p. 169), *Elaphria chalconia* (p. 181), and *Catocala subnata* (p. 620—no hosts or references). In a few instances the food plant list includes unlikely hosts not mentioned in any reference given; e.g., under *Carsia paludata* (p. 505) 7 hosts are listed, although in the one reference cited only *Vaccinium* is mentioned. The hosts of *Apaeecasia subaequaria* (p. 617) are given as ferns and grasses, but neither of the references mentions grasses (Rupert, 1949, specified bracken fern).

The casual transliteration of plant names can be tricky, and I noticed one instance where this led to an obvious mistake. The eastern skunk cabbage, *Symplocarpus foetidus* (L.), is listed in error as one of the food plants of *Arzama obliqua* (p. 480). The host actually reported in the literature (Guppy, 1948) was *Lysichiton* (sic) *kamtschatcense* Schott, a different member of the Araceae that is known as skunk cabbage on the Pacific Coast.

Throughout the work there are numerous typographic errors, especially in the spelling of scientific names, such as *atlanta* for *atalanta* (p. 119), *Catabens* for *Catabena* (p. 273), *focosa* for *fucosa* (p. 301), *idalis* for *idalia* (p. 342), *uo* for *io* (p. 363), *lutea* for *luteata* (p. 409), *maculatz* for *maculata* (p. 413), *radicans* for *radians* (p. 563), *rockesi* for *ruckesi* (p. 580), *Agertum* for *Ageratum* (p. 674), and *curimacula* for *curvimacula* (p. 809). I do not know whether these misspellings date from the final retyping or were reproduced verbatim from Tietz's original copy.

I noted the following errors of collation which owners of these volumes should carefully mark. They cannot be detected by the page numbering, which is uninterrupted.

(1) Pages 147 and 148 are transposed (giving the false impression that poplar and willow are the food plants for *Papilio brevicauda*, instead of for *Catocala briseis* which begins at the bottom of p. 148).

(2) Page 220 is misplaced and belongs between pages 210 and 211.

(3) The left column on page 207 does not refer to *Callophrys comstocki* as it reads, but to *Everes comyntas*, the name of which does not appear at all. Possibly a page is missing here but I have not found it.

(4) Pages 264 and 265 are transposed.

Although my criticism may seem lengthy, this is an important reference work of over 1,000 pages, promising a greatly simplified means of access to the literature of the first 150 years of research on the early stages of North American macrolepidoptera. Despite its faults and lack of coverage for the last two decades, the work will undoubtedly be extremely useful. Few entomologists concerned with life history information on Lepidoptera can afford to ignore it.

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BUTTERFLIES OF AUSTRALIA, by I. F. B. Common and D. F. Waterhouse. 1972. Angus and Robertson (Publishers) Pty. Ltd., Sydney, Australia, etc. 498 p., 41 plates (26 in color), 25 figs., 366 maps. Price: \$37.50 (U.S.). Distributed exclusively in the United States by Entomological Reprint Specialists, P.O. Box 77224, Dockweiler Station, Los Angeles, California 90007.

Australian lepidopterists are a fortunate breed: in the space of two years three fine books on their butterfly fauna have appeared. From a scientific viewpoint the



present volume is the best of the lot, though from an esthetic standpoint the McCubbin book is more pleasing and the plates more readable, and the D'Abrera book covers more territory (see reviews of these books, J. Lepid. Soc. 26: 200-202).

The introductory chapters on "Structure and Life History," "Biology," "Behaviour and Other Aspects of Physiology," "Geographical Distribution" and "Classification and Nomenclature" are well-written, concise and informative. The authors have wisely side-stepped the matter of continental drift in their explanation of the geographic distribution of Australian butterflies and the derivation of these insects from those in other regions.

The general systematic accounts are excellent, but the arrangement is somewhat inconsistent. Many workers will have difficulty adjusting to the arrangement of families (Hesperiidae, Papilionidae, Pieridae, Nymphalidae, s. l., Libytheidae and Lycaenidae), presumably from primitive to specialized. Within families different arrangements are followed. The Coeliadinae are generally considered more "advanced" than are the Trapezitinae in the Hesperiidae, but following Evan's *Catalogue* the Coeliadinae are placed first. Conversely, the satyrids are arranged from "primitive" to "derived" in accordance with my 1968 revision. These inconsistencies by no means detract from the usefulness of this book, they only serve to distress the taxonomist slightly.

Each species description is accompanied by a distribution map, hopefully setting a pattern for similar works in other regions (Riley and Higgins also did this in their European book). Unfortunately, all the maps are uniform—more information on very localized species could have been derived from a map of a smaller area. The authors are nevertheless to be congratulated on the inclusion of maps.

The figures are quite usable. Genitalic figures are given for only those species that cannot be distinguished superficially. The larval and pupal figures could have been stronger had they been accompanied by line representations of chaetotaxy, perhaps in the text.

The section on "Collection and Study" is informative and applicable to any region, the "Glossary" defines technical terms and the "Food Plant List" summarizes the known butterfly-plant relationships. The currency of the book is attested to by inclusion of new information that came to the authors' attention after completion of the manuscript.

There are few typographical errors, one of the most glaring being "pleural" instead of "plural" on page 56. Such errors must be accepted; some are completely unavoidable.

On balance, the authors have done an excellent job, and if one is interested in Australian butterflies, he must have this book. It can stand alone as a reference for the area and is a worthy successor to G. A. Waterhouse's forty-year-old *What Butterfly Is That?* This work should be a standard forty years from now.

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## NOTES AND NEWS

### FIRST KARL JORDAN MEDAL AWARDED TO HENRI STEMPPFER

The Karl Jordan Medal (J. Lepid. Soc. 26: 207-209) was awarded for the first time at the annual banquet during the Society's 24th Annual Meeting in Sarasota, Florida, on 23 June 1973. The Jordan Medal was presented to M. Henri Stempffer of Paris, France, by the sponsor of the medal, Mr. A. C. Allyn.

M. Stempffer was awarded the medal for his various works on the Lycaenidae, especially those of Africa, culminating in his "The Genera of the African Lycaenidae



Presentation of the Karl Jordan Medal, Sarasota, Florida, 23 June 1973. From left: Henri Stempffer, Mme. Stempffer, A. C. Allyn.

(Lepidoptera: Rhopalocera)" (1967, Bull. British Mus. [Nat. Hist.], Suppl. 10: 322 p., illustrated). These careful pieces of work have become standards for students of the African fauna in a relatively short period of time.

It was gratifying to many of us who had long used M. Stempffer's works to have the opportunity to meet him in person. Though he has never had a formal academic connection, M. Stempffer's work has placed him in the forefront of workers on the African fauna, and he is truly representative of the type worker for whom the Karl Jordan Medal was intended.

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It is time again to thank a number of persons for their assistance to me during the past year. The members of the Editorial Committee of the Journal willingly reviewed most of the submitted manuscripts. In addition, the following individuals reviewed one or more manuscripts upon request: D. E. Berube, L. P. Brower, H. K. Clench, H. A. Freeman, D. F. Hardwick, C. G. Kellogg, C. D. MacNeill, E. G. Munroe, J. A. Powell, F. H. Rindge, and O. R. Taylor. The helpful assistance of all of these people is gratefully acknowledged. Two editorial assistants, Nancy Wells and Elaine Doyle, served with patience and skill, and I especially thank them for their efforts. The cover drawing (*Sphinx vashti* Strecker) was kindly provided by William H. Howe.

THEODORE D. SARGENT

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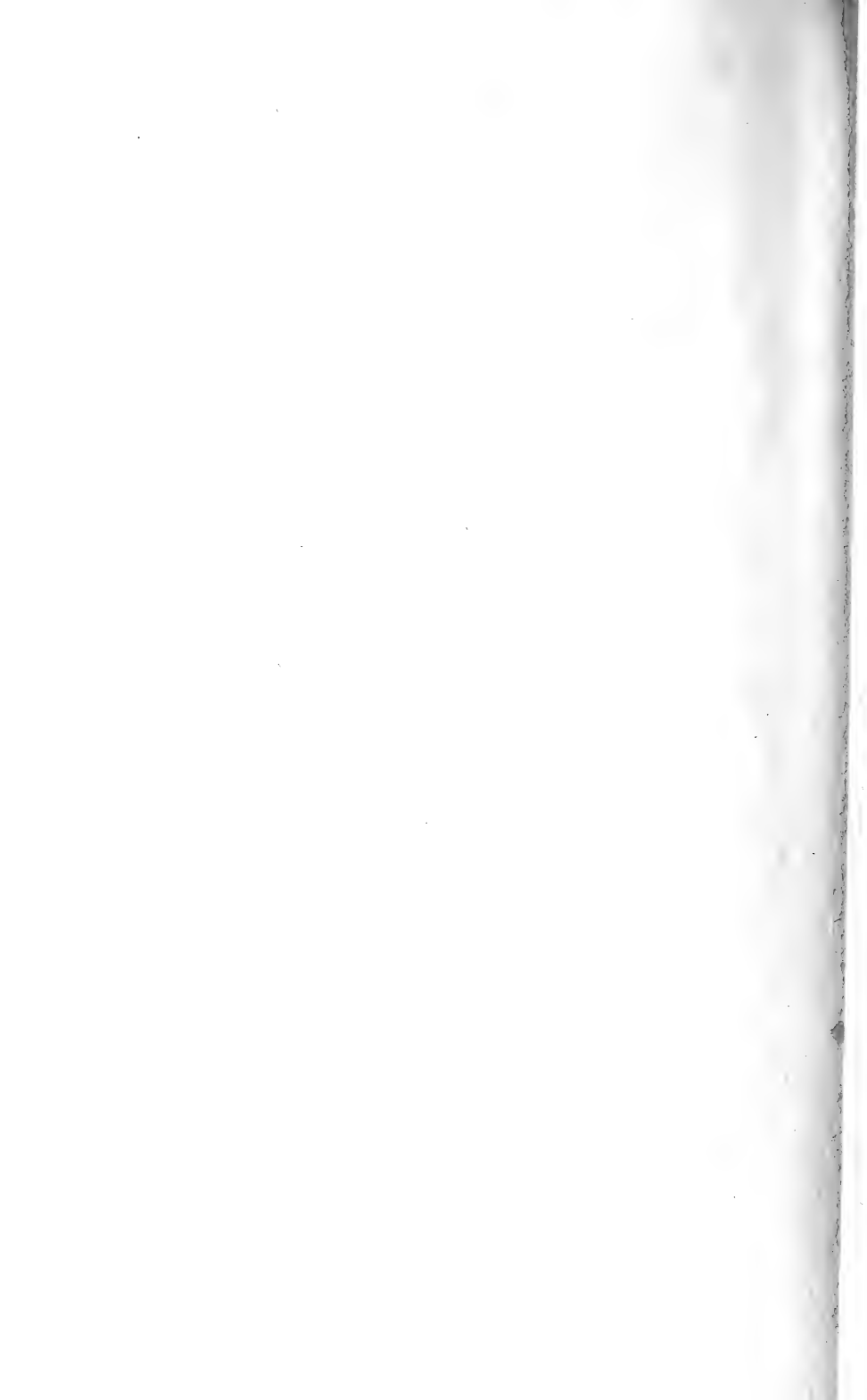
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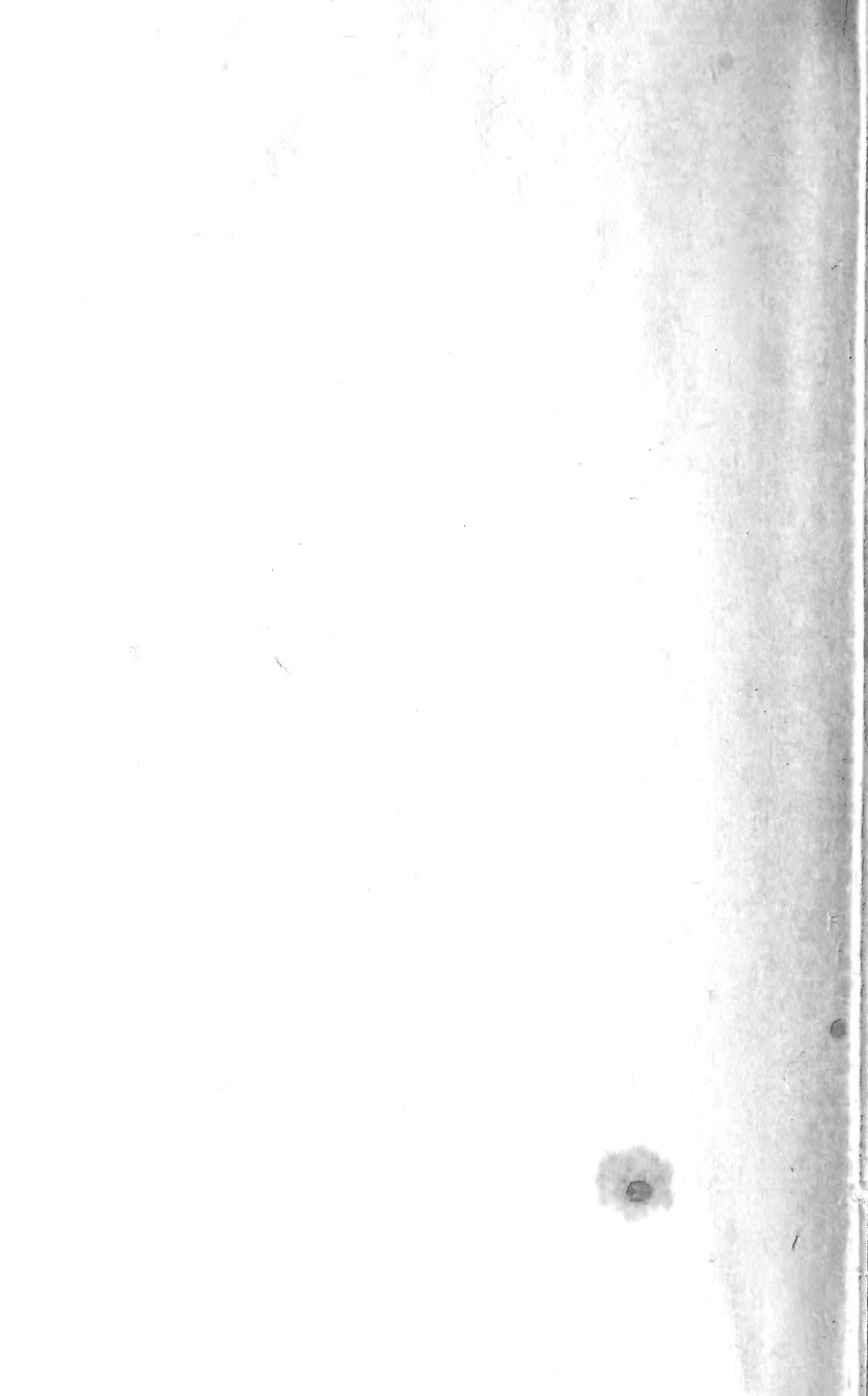
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